INTRODUCTION

CEMENT CONCRETE
& AGGREGATES AUSTRALIA

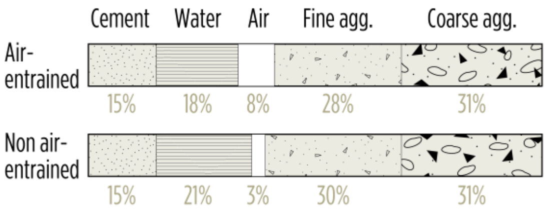
In its most basic form, concrete is a mixture of cement ('Portland' or blended), water, and fine and coarse aggregates (sand and crushed rock or natural gravel). Concrete is plastic when first mixed, but it then sets and hardens into a strong, solid mass. In the plastic state it can be moulded or extruded into a variety of shapes. When hardened, it is strong and durable, able to support substantial loads and, at the same time, resist the effects of fire, weather, wear, and other deteriorating influences. Because of these properties concrete has become a construction material of great versatility and wide application.

The properties of concrete in both the plastic and the hardened states are dependent on the physical characteristics, the chemical composition and the proportions of the components used in the mixture. Plastic-state properties must be appropriate for the methods of handling, placing, compacting and finishing to be used in the job. Hardened-state properties must be appropriate for the purpose for which the concrete is to be used – i.e. it must be strong enough to carry the loads imposed on it and durable enough to resist the deteriorating influences of wear and weather.

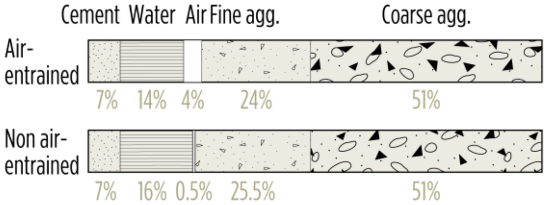
If not properly placed and compacted (as discussed in Part V of this Guide), concrete will not achieve its potential strength and durability. It is important, therefore, that when delivered to the construction site, plastic concrete is sufficiently workable for it to be placed and compacted using the means available and in a timely manner.

Workability is achieved by having sufficient 'cement' paste (cementitious material and water) in the mixture to lubricate the particles of aggregate which allows them to move freely as the concrete is placed and compacted.

Generally, the greater the volume of cement paste in the mixture, the more workable will be the concrete. However, it is the volume of water in the paste which tends to be the dominant factor – the more fluid the paste, the more workable the concrete.



SMALL AGGREGATES IN RICH MIX (High Proportion of Cement Paste)



LARGE AGGREGATES IN LEAN MIX (Low Proportion of Cement Paste)

NOTE: From the above diagrams, which show mixes at the same slump, the following can be seen – (a) Coarse aggregate is generally the dominant material; (b) air-entrained mixes require less water to achieve a given slump; (c) even non air-entrained mixes contain some air. Mixes containing smaller aggregates typically require a higher 'cement' content to achieve a given strength than mixes with larger aggregates - as more paste is required to cover the higher surface area present with smaller aggregates

RANGES OF CONCRETE MIX PROPORTIONS

Achievement of many of the desirable hardened-state characteristics of concrete, particularly its strength and durability, depends to a great extent on the development of physical and chemical bonds both within the cement paste as it hydrates (i.e. reacts chemically with water) and between the cement paste and the aggregate particles as the concrete hardens.

For a given mix, maximum bond development will occur when the water content of the cement paste is at the minimum needed to achieve adequate workability and all air is expelled from the system. In this respect, cement paste is like any other glue – dilution weakens it.

When proportioning concrete mixes there are competing requirements that must be recognised. More water increases concrete workability (allowing it to be properly placed and finished) but as already noted, it also dilutes and weakens the cement paste. In concrete mix design (or proportioning – Part III of the Guide) it is necessary to strike a balance between the workability and strength/durability requirements of the project and/or specification.

In modern concrete technology, mix designers have at their disposal a range of materials other than the basic 'cement plus water plus aggregates' with which to modify the properties of concrete (Part II of this Guide). Modern concrete mixes almost invariably contain pozzolanic and other cementitious materials, one or more chemical admixtures, and where needed, special aggregates. Also, in structural design it is common practice to reinforce concrete in order to optimise concrete performance. Steel reinforcement and prestressing have been the preferred methods of providing this reinforcement. In more recent years other forms of reinforcement have also been developed to improve structural performance such as various types of fibres. The nature of these newer materials and their effects on the properties of concrete are discussed in subsequent Sections of this Guide.

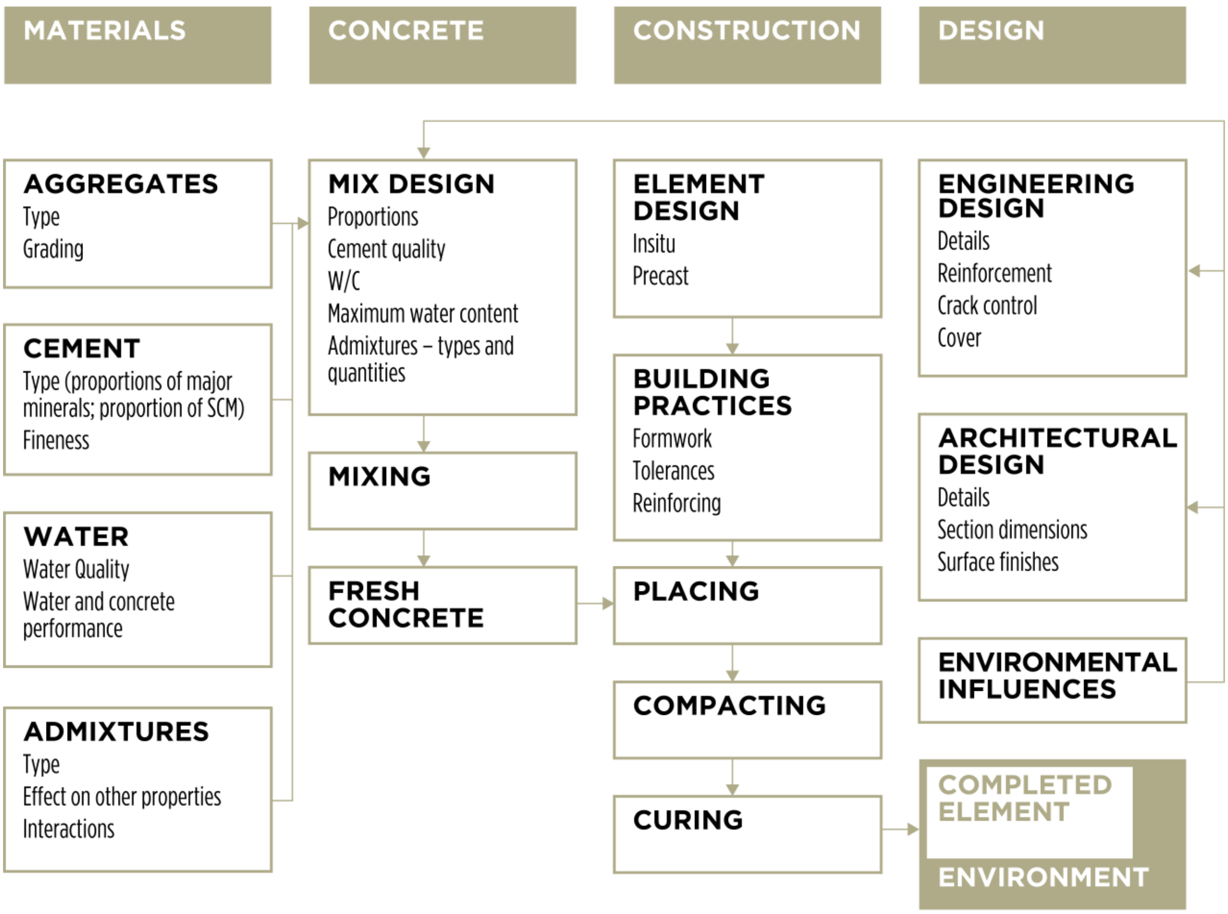
The performance characteristics able to be achieved with modern concrete could have only been dreamed about by concrete technologists as little as 20-30 years ago. High performing cementitious materials and admixtures that allow highly workable mixes to be produced at very low water-to-cementitious materials ratios (W/C) have allowed concrete performance to soar to new heights – literally. High-rise structures of the dimensions now being built could not have been constructed with older concrete technologies. Concrete can also now (a) be 'put to sleep' for 2-3 days and then 'woken up' and used; (b) be successfully placed under-water (Part VI) and (c) be used to produce thin, high strength post-tensioned concrete floors in high-rise structures, saving materials, time and money. There seem to be few limits to how modern concrete can be used.

These advances do not mean that concrete as we know it does not face challenges. Concrete has been the 'victim of its own success' in some ways. With over 30 billion tonnes of concrete being placed throughout the world each year, supported by the manufacture of over 4 billion tonnes of cement, the sheer volume of materials and their manufacture present some environmental challenges. These have been discussed in Part X of this Guide. Developments of new alternative binders that may one day replace 'Portland' cement are also discussed in Part VII, Section 23.

Despite the great advances in concrete technology and its ubiquitous use, concrete construction cannot be successfully carried out without consideration of many other factors. The diagram at the end of this 'Introduction' demonstrates the inter-dependence of concrete the material with a range of other factors that must be considered when building a concrete structure. Ultimately, the concrete structure must exist in a particular environment and these environmental conditions must be known. Architectural and engineering design must then be used to ensure that the concrete structure (a) is suited to the local environment, and (b) has design elements that allow it to function as its owners expect (Part I of the Guide). It is then up to the concrete technologist to create a concrete mix that suits these various needs and then for the project team to ensure that the concrete is properly placed, finished and cured to maximise its performance. It is the integration of all of these elements that creates the ultimately successful concrete structure.

The flexibility of concrete is such that (a) being able to be moulded when in the plastic state allows structures of many shapes and sizes to be built, and (b) its strength and durability allows these structures to be serviceable and durable for long periods of time. These benefits, along with its relatively low cost and 'local' manufacture, account for the world-wide success of concrete as a building material. However, the world does not stand still, and concrete technology continues to advance. Some recent technology improvements are described in Part VII, Section 24 of this Guide.

This edition of the Guide has been expanded to encapsulate many of the new advances in concrete technology and explains how concrete fits into the modern construction industry. The main purpose of this Guide is to provide practically based information about modern concrete technology and many of the construction techniques and processes used in concrete construction. It is worth noting that seldom is there a unique solution to achieving a satisfactory structure. Each case needs to be considered individually. The choice of materials will be influenced by local availability, while the techniques employed to carry out the necessary associated processes (e.g. curing) will be influenced by the construction process and program being undertaken. In every case, consideration needs to be given to the ease with which a process can be carried out on-site. It is a truism that designing structures to be 'buildable' goes a long way to ensuring that the structure will achieve its design potential and perform appropriately throughout its design life. Therefore, designers and construction personnel need to understand the construction processes by which concrete structures are created, as well as having a good understanding of the material and how it should be used. This Guide is a resource to be used by those seeking further information about concrete, concrete technology and concrete construction.



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