



## Forgotten Material History of Historic Concrete

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### Summary

In this paper, an overview is given of the material history of early historic concrete, i.e. the late 19<sup>th</sup> and early 20<sup>th</sup> century. Interventions of historic concrete structures are increasing, both for repair and conservation. Whereas the structural appraisal is commonly discussed, the material composition is less addressed. Better information on the historic concrete itself is necessary when evaluating an historic concrete structure, as the previously used binders can influence the durability differently. A challenge hereby is that many details of the material history have been forgotten. Especially in the period before the 1940s, many rarities were applied and the pace of technological progress is frequently misconceived. The role of the national context is underestimated. To improve pre-investigations of historic concrete structures, timelines for the binders used and changing perceptions regarding aggregates are presented.

**Keywords:** historic concrete; construction history; concrete repair; concrete conservation; binders; aggregates

### 1. Introduction

For both concrete conservation and repair, a correct identification of the constituents used is essential. It can explain present degradation which might be more severe than known from modern concrete. For choosing compatible repair methods, reliable information is necessary. Especially for conservation this is relevant as the loss of original material and aesthetical impact should be minimised, and the remaining service life of historic structures increased. Problems with the characterisation of historic concrete and related obsolete concrete terminology are not uncommon. Causes are our limited knowledge of the material history of concrete and lacking reference data. More knowledge is however relevant as interventions with historic concrete structures will increase, either in a normal repair context or during conservation.

Reviewing the material history of concrete, significant changes can be encountered in the first decades of the 20<sup>th</sup> century. Empirical knowledge was replaced with scientific findings. Due to the increase use of concrete, durability problems were identified, such as the poor behaviour of Portland cement in marine water, initiating the development of new cement types. Attention was given how to optimise the mix design. Understanding these milestones of concrete technology is not only interesting for historical research, but relevant for interventions of historic concrete structures, as their properties can deviate from present day concrete.

Concrete is a composite material, and each constituent underwent a technological development of its own. A strong dynamic in the development and application of new scientific findings can be observed in the 1920s and 1930s. In parallel, the amount of reinforced concrete structures increased. Despite the international character of research, reinforced concrete remained a national material. National codes determined the design and choice of materials, and most raw materials were of local origin, or imported from preferred countries. The national sophistication of the field influenced the quality of design and execution. These factors have to be considered when evaluating historic concrete structures and when consulting reference materials. Many structures have been replaced meanwhile, some are still operational, and of which several are being reviewed whether they are of historic significance.

National preferences and regulations have to be considered as not all constituents were applied at the same time in different countries. In addition, the quick development of material science in the first half of the 20<sup>th</sup> century is underestimated. Generic reference works giving guidance during investigations are limited. A more differentiated approach and understanding of the different periods is still necessary. More data is required of the properties of the aged concrete in-situ, and which aspects affect negatively or even positively its durability. A reconstruction of the historical context can give guidance to formulate a hypothesis of the possible constituents used, and thereby help to increase the quality of pre-investigations.

In this paper, the main changes of the constituents – cements and cement content, aggregates, mixing water - will be outlined. An emphasis will be made on the first half of the 20<sup>th</sup> century, as here the underlying concepts of concrete technology were developed, and many details and materials used have been forgotten. A focus will be made on the Dutch situation. Figure 1 shows the variety and period of application of different binders used for historic concrete. Figure 2 represented the main changes regarding coarse aggregates and grading. The offered timelines can give orientation of what can be expected of a concrete dating from a specific period. Thereby, awareness is created to consider different constituents during investigations.

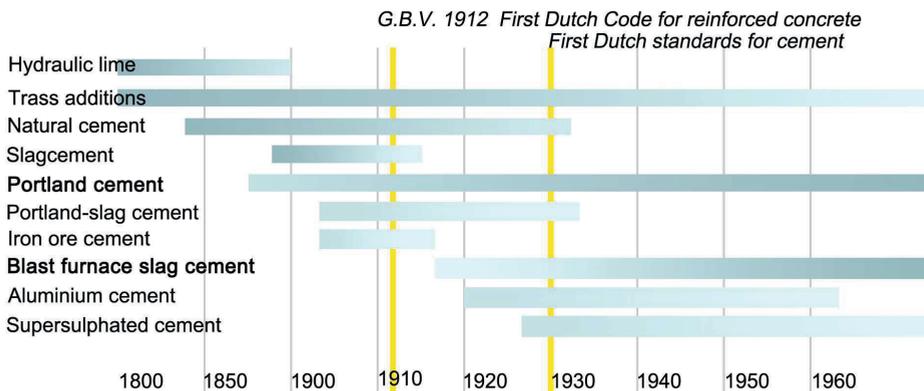


Figure 1. Timeline indicating possible binders used for historic (reinforced) concrete in the Netherlands. G.B.V. stands for Gewapend Beton Voorschriften, Netherlands Code of Practice for reinforced concrete.

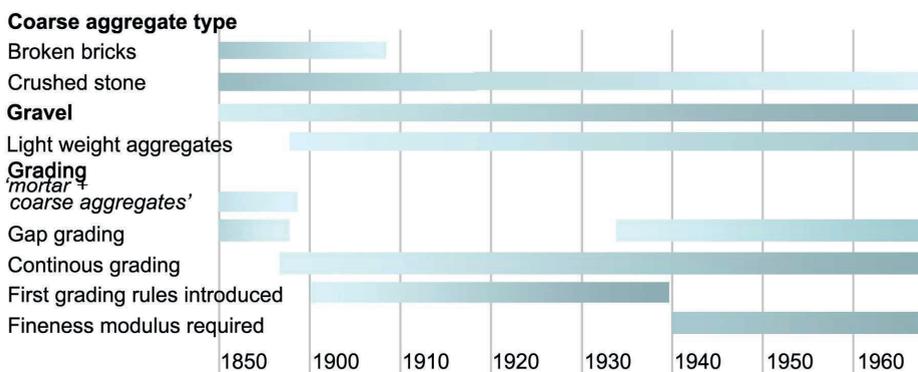


Figure 2. Timeline indicating possible types of coarse aggregates and concepts of grading binders applied for historic (reinforced) concrete in the Netherlands.