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Briefing

Embedded retaining walls: guidance for economic design

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CIRIA Funder's Report CP96 was issued to the core members of CIRIA in March 2002. It is now, or will shortly be, available to a wider audience. This note describes the background to this research project and details the objectives, intended readership and applicability of the resulting report. The report particularly addresses the subject of economic design, and some of the key recommendations are noted below.

1. BACKGROUND TO PROJECT

CIRIA Report 104 *Design of Retaining Walls Embedded in Stiff Clays*[1] has been hugely influential. Although strictly applicable to the design of singly propped (Fig. 1) or cantilever walls embedded in stiff overconsolidated clay, the principles presented in the report have been applied to a wide range of wall types and soils in the UK and overseas, including multi-propped embedded walls and even non-embedded walls.

Since publication of CIRIA Report 104, several retaining wall design guidance documents and codes of practice relevant to embedded walls have been issued, for example BS 8002 (1994)[2] and EC7 (1995).[3] In addition, many technical papers and textbooks have been published. These documents do not provide consistent and harmonious design advice, and many omit detailed treatment of modern numerical analysis methods. The multiplicity of documents, and the guidance provided therein, results in confusion (which is costly to designers) and poor economy in construction (which is costly to constructors and clients). There is therefore a need for a coherent and authoritative document that collates the best ideas and experiences available in British practice and provides a clear path through the many alternative design approaches. CIRIA fundet's Report CP96 aims to do this.

Fig. 1. Typical propped excavation (courtesy of Bachy Soletanche Limited)

2. OBJECTIVES

The research for Report CP96 was commissioned by CIRIA in November 2000. The project was undertaken by Ove Arup and Partners Limited with assistance from the University of Southampton and Bachy Soletanche Limited. The steering group that guided the work represented clients, consultants, contractors and academia. The authors consulted widely via a questionnaire, consultation workshop and literature searches.

The report provides guidance on the design of embedded retaining walls. It aims to achieve economy in the resulting retaining structure and its support system while maintaining various levels of simplicity, as far as possible, but also facilitating more complex approaches where they give an advantage.

The report

(*a*) provides best-practice guidance for the design of embedded retaining walls consistent with recent research and current analytical techniques
(*b*) describes and compares existing design methods for such walls
(*c*) discusses available wall types and construction methods
(*d*) provides construction costs data to guide the reader in selecting wall types appropriate to particular requirements.

The report supersedes CIRIA Report 104.[1] An outline of the report's contents is shown in Fig. 2.

3. INTENDED READERSHIP

The report is intended for use by those concerned with the selection, design and construction of embedded retaining walls. In addition to providing guidance to designers, it is intended that the report will also

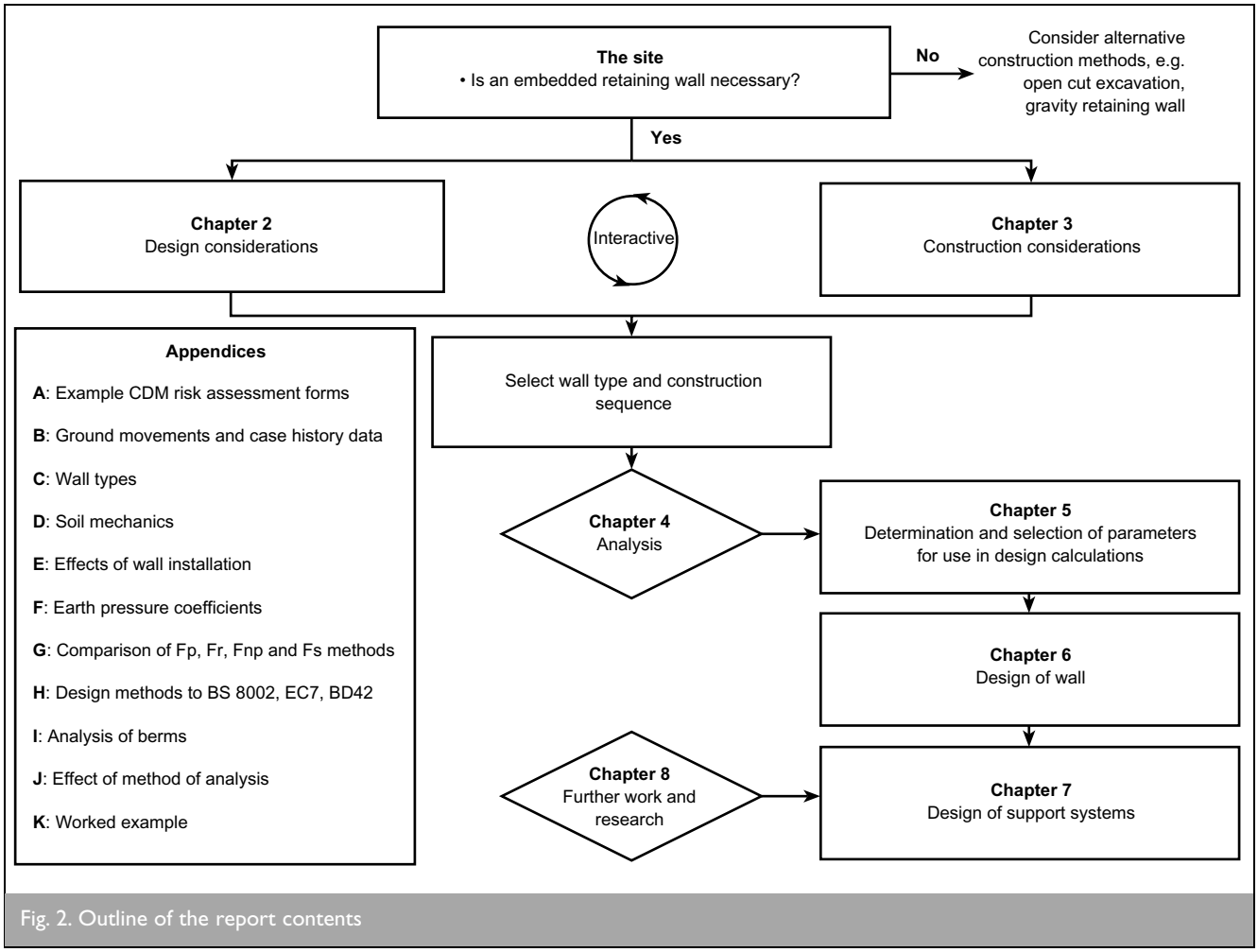

Fig. 2. Outline of the report contents

(*a*) provide background information on wall selection, construction methods and associated ground movements for clients and owners and their technical advisers
(*b*) present geotechnical principles and guidance to structural and geotechnical engineers and to students who wish to gain an appreciation of the issues relevant to the selection, design and construction of an embedded retaining wall
(*c*) act as a reference for more experienced geotechnical engineers.

4. APPLICABILITY

The report covers the design of temporary and permanent cantilever, anchored, single- and multi-propped retaining walls that are supported by embedment in stiff clay and other competent soils. Its principles are applicable to a wide range of fine-grained and coarse-grained soils in the UK and overseas. The design of walls embedded in soft clay and those socketed into rock is beyond the scope of this report.

Few walls are constructed entirely in stiff overconsolidated fine-grained soils. Although the wall may be embedded in such soils, it is likely that it will also retain other soils, for example made ground, river gravels and other alluvial deposits. The principles presented in the report also apply to this common situation.

Ground engineering requires a thorough knowledge and understanding of basic principles and the application of sound engineering judgement based on experience. It is emphasised that the report is not a substitute for professional knowledge.

5. ECONOMIES

Economy can be achieved by

(*a*) ensuring ease of construction and minimising construction duration
(*b*) optimising the use of materials
(*c*) applying appropriate design effort.

The biggest economies will be available at the outset of a project during the selection of an appropriate method and sequence of construction, wall type and the optimisation of the temporary and permanent use of the retaining structure.

Achieving economy requires commitment and adherence to an approach that necessitates a holistic view to be taken of project requirements. Whole-life costs should be considered. A robust design that minimises long-term maintenance requirements may be appropriate in some circumstances. A design that minimises wall dimensions and material use but which increases construction duration because it is difficult to build may not result in overall economy. It should be recognised that the designer cannot achieve the most cost-effective solution in isolation from the client and the constructor.

The client, designer and constructor and, where appropriate, the architect and the quantity surveyor should be involved as early as possible to

(*a*) optimise the temporary and permanent use of the retaining structure (for example the adoption of one wall instead of two to serve both the temporary and permanent requirements) which is also compatible with long-term maintenance requirements
(*b*) establish appropriate design and performance criteria for the retaining structure, for example acceptable limits for wall deflection and associated ground movements, and crack width criteria
(*c*) consider the appropriate wall type
(*d*) consider the appropriate method and sequence of construction to ensure buildability with minimum construction duration.

Where the design of a wall is governed by temporary works considerations, a risk-based approach to design may result in significant savings. Use of the observational method may result in the most cost-effective design solution for temporary and permanent works. However, in this circumstance, appropriate contractual arrangements should be in place to permit the necessary integrated interactive approach to be taken on site between design and construction.

A clear, unambiguous design method that eliminates confusion will lead to savings in unnecessary design effort. The choice of analysis method can result in significant savings in the wall structure. For example, propped or anchored walls designed using soil–structure interaction methods will be shorter, and computed wall bending moments will be smaller, than those designed using limit equilibrium methods.

6. CONCLUSIONS

It is hoped that this document will be treated as a key reference for retaining wall designers so that the aim of providing guidance for economic design is realised.

REFERENCES

1. PADFIELD C. J. and MAIR R. J. *Design of Retaining Walls Embedded in Stiff Clays*. Construction Industry Research and Information Association, London, 1984, CIRIA Report 104.
2. BRITISH STANDARDS INSTITUTION. *Code of Practice for Earth Retaining Structures*. BSI, Milton Keynes, 1984, BS 8002.
3. CEN. Eurocode 7 *Geotechnical Design Part 1 General Rules*. DD ENV 1997–1, 1995.

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