

REHABILITATION OF COASTAL STRUCTURES

Progress Report for period

1st. March - 14th April 1992

Ian W Stickland
Consulting Engineer

April 1992

Progress Report 386/1/A



NRA

National Rivers Authority

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ENVIRONMENT AGENCY



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NRA R & D PROJECT 386 - Rehabilitation of Coastal Structures

PROGRESS REPORT No. 1 - 14th April 1992

1.0 INTRODUCTION

1.1 Project Objectives

The purpose of the project is to produce a guide to the rehabilitation work on coastal defence structures undertaken by NRA. The project is to be carried out in two phases with the specific objectives of Phase I being as follows:-

- (a) To undertake a literature review of the subject area.
- (b) To identify major faults threatening failure of sea defence structures.
- (c) To identify basic methods of solution to each type of sea defence structure.
- (d) To produce from the Literature Review subject areas not covered adequately and assess future requirement to rectify situation.
- (e) Compile a contents list for the proposed guidelines based on NRA's needs.
- (f) Assist the Project Leader in the production of Terms of Reference for Phase 2 and shortlist potential contractors.
- (g) Produce a Project Report for the Phase I work.

1.2 Definitions

At a start-up meeting on 10th March 1992 the following definitions were discussed and agreed.

Coastal Structures:- To include both sea walls and revetments (see definitions below).

Seawall:- A shoreline structure whose primary purpose is either protection against erosion or the alleviation of flooding, or a combination of both, in which wave action is the dominant design consideration.

Revetment:- A cladding of stone, concrete, or other material to stabilize and protect shorelines, embankments or shoreline structures against waves and currents. It may form part of a sea wall structure.

Rehabilitation:- Major works to restore a wall to its original state (Renovation) or upgrade it to a new standard or function. Such works usually being classified as 'Capital Works'.

Maintenance:- Routine inspection, structural evaluation and small scale works to repair parts of a wall. Such works usually being classified as 'Revenue Works' and exclude rehabilitation.

2.0 LITERATURE REVIEW

There is no single publication which deals solely with the rehabilitation of coastal structures but there are three principal documents which cover the subject area but from different standpoints.

- (a) CIRIA 'Seawall Design Guidelines' (To be published in May 1992).
- (b) CIRIA ' Special Publication 83 'Manual on the use of rock in coastal and shoreline engineering' (Published 1991).
- (c) CIRIA 'Old Waterfront Walls - Management, maintenance and rehabilitation' (Publication date 7th May 1992).

Additional publications to be reviewed will include

- (1) NRA/Halcrow guide on coastal revetments (Project Leader John Ash - Norwich)
- (2) CIRIA Technical Note 124 - Coastal Revetments
- (3) CIRIA Technical Note 125 - Sea Walls - survey of Performance and Design Practice.
- (4) American Army Corps of Engineers - Shore Protection manual.

2.1 Literature Review - Requirements

Given the number of documents covering the subject area the overall requirements of the literature review will be to define and agree the following.

- ◆ What sort of guideline is required by NRA?
- ◆ Does the information already exist?
- ◆ If so, does it cover the specific requirements or are there gaps?
- ◆ Is it dispersed among a number of separate documents?
- ◆ If it is, is there a need/justification for bringing it together into a single NRA document?

As a first task therefore I have concentrated on establishing, in broad terms at this stage, the basic requirements of an NRA guideline and used this to judge the adequacy of the three principal publications.

2.2 Literature Review - NRA Guideline Requirements

There are a number of judgements to be made when determining the format and content of a guideline on the rehabilitation of coastal structures. Firstly, and very importantly, the level of readership. This has been defined in the contract terms of reference as "the graduate engineer level but not necessarily with coastal defence experience".

Secondly, the range of subject areas covered by the project is considerable, and no one publication could ever hope to cater for all of them, particularly where a high level of specialist knowledge and experience is involved. In such instances the guideline should seek to alert the reader to the need for expert advice.

Thirdly, the whole question of the initiation of rehabilitation works presupposes a history of inspection, maintenance and repair and monitoring. In terms of an in-house NRA document this brings into focus the division of responsibility between "Operations" and "New Works" personnel on the one hand, and the existence of national data bases (National Seawall Survey) and regional or district strategy or coastal management studies, on the other hand. (SDMS and Mablethorpe to Skegness Strategy study in Anglian Region). Further aspects such as Levels of Service, residual life of structures etc. are unique to NRA and further discussion on this is essential.

Subject to the above comments I have prepared a table of the main subject headings reflecting the overall requirements and begun to assess the extent to which each publication deals with the subject matter taking account of:

- ◆ the level of readership
- ◆ the depth of coverage in terms of technology and good engineering practice
- ◆ the extent of shortfalls or gaps in detail
- ◆ adequate exposure of limitations in technology

Because of the inadequacy or absence of indexing in two of the publications (which are still at final proof stage) my assessment work has been somewhat slower than anticipated.

A copy of the table is included as Fig No. 1.

3.0 COMMENTS ON WORK TO DATE

My initial work, after defining the guideline requirements was to check on the range of structure types covered in each publication and the extent of overlap.

3.1 Structure Type

The range of structure types covered by the three publications is as follows:

(A) Sea wall Design Guidelines

- ◆ Seawalls - vertical and sloping
- ◆ Armoured slopes - Porous
- ◆ Stepped slopes - Non Porous
- ◆ Smooth slopes - " "
- ◆ Gravity structures - " "

- ◆ R.C. Retaining walls - Non Porous
- ◆ Sheet piling - " "
- ◆ Porous gravity walls
- ◆ Cribwork & Breastwork - timber with/without rock hearding
- ◆ Groynes - Timber

(B) Manual on use of rock in coastal and shoreline engineering

- ◆ Breakwaters
- ◆ Seawalls, groynes and shoreline protection structures
- ◆ Dam face protection
- ◆ Gravel beaches
- ◆ Rock-fill offshore engineering

(C) Old Waterfront Walls

- ◆ Quays, docks and locks
- ◆ Breakwaters
- ◆ Seawalls for coastal defence (vertical)
- ◆ Retaining walls and flood defences
- ◆ Skin walls
- ◆ Bridge piers and abutments

The range of structures covered is therefore very comprehensive and importantly includes old vertical structures and their method of construction and materials.

In terms of rehabilitation work the Seawall Guidelines clearly covers the most relevant types of wall. However given the current trend towards the use of rock then there is obviously important additional coverage in the Rock Manual. The Old Waterfront Walls publication is more directed towards the vertical or near vertical type of structure but has a relevance as it covers both masonry and brick construction.

The extent of overlap is minimal and each publication recognises and refers to the others. No one document comprehensively covers all structure types although the Seawall Guideline is the best in this respect.

3.2 Approach adopted in publications

The approach adopted in the presentation of material in both the Seawall Design Guidelines and the Rock Manual is based on logic diagrams of typical design office practice and procedures. Both books emphasize the need for logical and systematic procedures centred around an initial and fundamental requirement to establish the nature and the scale of the problem. In this respect there is a tendency to concentrate on "New Works" as opposed to rehabilitation with the result that historical data on maintenance, repair, inspection and monitoring, whilst highlighted, is not dealt with in detail. The Old Waterfront Wall publication deals with this latter aspect in greater detail but is restricted by virtue of the range of structures involved.

<p>CIRIA PUBLICATIONS</p> <p>MAIN SUBJECT HEADINGS.</p>	<p>SEAWALL DESIGN GUIDELINES</p> <p>Full Range of Coastal Structures.</p>	<p>MANUAL ON ROCK IN COASTAL ENGINEERING</p> <p>Mainly Rock Structures</p>	<p>OLD WATERFRONT WALLS</p> <p>Principally Vertical or Battered Walls.</p>
STRUCTURE TYPES	Section 2 - Outline of Structures Section 5 - very detailed presentation.	Section 1.3 Details in other sections	Section 1 - outline Section 2 - examples & details.
REHABILITATION	Section 5.7	Section 7.	Section 4.10 Introduction Section 8 - Detail. Sec. 4. - Contract Types. See Fig. 144
MAINTENANCE & REPAIR	Reference to construction for maintenance but no details on maintenance methods	Section 7 Data gathering see. p.185.	Section 4.11 Table of grading of repair and rehabilitation. See Figs. 144 & 148.
INSPECTION & MONITORING	Section 4.11.1/2/3/4	Section 7. Appendix 6 - rubble structures.	Section 5.0. Fig. 149 Inspection report format good coverage.
INSPECTION METHODS	Some general info in Section 4	Appendix 6.	Section 5.0 and 5.7.
FAILURE MODES & MECHANISMS	Section 3.2.2. - Causes. good logic diagrams Section 5.1.5 good logic diagrams.	Section 2.2 - Rock Structures. Fault Tree. Sec. 2.2.3	Section 7. no fault tree approach. Sec. 7.3 p.77. also results of Questionnaire App. 3.
DATA COLLECTION INVESTIGATIONS	Section 4 - vary detailed	Section 4 in total Appendix 4 & 5. good fig. N°99. p.184	Section 6.
COASTAL / PHYS PROCESSES	Sec 4.9.2/3/4 " 4.4.6/7. Very detailed.	Section 5.	Section 6.8. very limited by comparison with other two books.
LEVELS OF SERVICE	not covered directly as an item.	not covered.	not covered in detail see. Fig. 145
DESIGN CRITERIA	Section 5.1.4. includes design philosophy. Section 4.5.1/2/3/4/5	Section 5. Section 6.	Appendix 1. but very limited
DESIGN - OUTLINE & DETAILED	Section 3.4.1/2/3/4 Section 4.10 Section 5.2 Section 6.0 Detailing.	Section 1.2.1 Section 2.9/1/3 Section 5 and 6. Sec. 6.2 - coastal structures.	no significant details
MATERIALS	Section 7. - Full range of materials covered in detail.	Sections 3 & 4 Good diagram on material evaluation. Also geotechnics	Very limited. Refers to BS. 6349. See also. Sec. 2.1. etc.
ENVIRONMENTAL ASSESSMENT	Section 3.3.0 to 6. good detail.	Section 2.4 Appendix 7.	not covered.
ECONOMIC APPRAISAL	Section 8. very detailed particularly in terms of UK practice	Refers on p.20 (Section 2) to SWG for better BCA info.	very limited Trigger for rehabilitation
EVALUATION & DECISION MAKING	Different aspects covered in various relevant sections.	Covered in a number of sections	Section 7.3. Figs 146 & 147 results of Questionnaire.
HYDRAULIC MODELLING	Appendix B Covers both mathematical and physical.	Section 5.1.4 v. limited Section 5.2.5/6. maths on geotechnics.	no reference.
SPECIFICATIONS (MODEL)	No typical specs. as such but references to relevant B.S.'s.	Appendix 1. 2. & 3. v. good.	Very limited. Sprayed concrete. Spec. ref. p.88.
STRUCTURE CONDITION ASSESSMENT	Section 5.1 on life, risk & Fault Trees. Section 8.9.3/5 on residual life.	Section 7.2.	Section 7.0. Also results of Questionnaire. App. 3.

The design process diagram from the Seawall Guidelines is reproduced here as Fig. 2 and the equivalent Rock Manual diagram as Fig. 3. In the case of the Seawall Guidelines the diagram (Fig. 2) is reproduced at the beginning of each section or chapter of the book with the appropriate box highlighted so that the reader can see at a glance, not only where he is in the design process but also reminds him of other aspects of relevance.

Having compared the different approach adopted in the three publications I am now in the process of developing a more detailed assessment of the content of each section based on my table of NRA guideline requirements.

3.3 Initial comments on detailed assessment

The comments which follow reflect a broad view at this stage rather than detailed comments on specific areas.

3.3.1 Rehabilitation

There appears to be, in the Seawall Guidelines, a sufficiently detailed coverage of the majority of important aspects which would be involved in rehabilitation works. However as it points out there are certain considerations which are unique to rehabilitation which require more detailed coverage. Typical examples of this are 'inspection methods', greater degree of flexibility in financial control and contractual matters, and safeguarding the existing structure and minimising risk during construction.

3.3.2 Inspection

My first impression is that none of the three publications deal with inspection and inspection methods in sufficient detail. The Old Waterfront Walls gives good examples of non destructive testing and indicates limitations in techniques.

3.3.3 Specification

There appears to be a marked absence of "model" specifications either for construction work or materials with the obvious exception of the rock manual although this is restricted almost solely to materials specification.

3.3.4 Materials

The most comprehensive coverage on materials is contained in the Seawall Guidelines and this, together with the very detailed information on rock in the Rock Manual, very adequately covers this subject. However I can find virtually no detailed information on the use of sprayed concrete encasements although this is a very common method for renovation.

3.3.5 Failure Modes

On the question of failure modes and mechanisms both the Seawall Guidelines and the Rock Manual promote the concept of the Fault Tree approach. This is supported in the Seawall Guidelines by excellent diagrams which are also reproduced in the Rock Manual. In the case of the Rock Manual the "Fault Tree" approach is carried a stage further by the inclusion of methods to assess the statistical probability of particular failure events (i.e. standard Dutch practice).

3.3.6 Data Collection

Data collection, analysis and interpretation is very detailed in the Seawall Guidelines, particularly in terms of UK practice and is marginally better on this subject than the Rock Manual.

3.3.7 Design

With regard to design, both outline and detailed design, the Seawall Guidelines is the most comprehensive as it not only considers the plan shape and location of structure but deals with the cross-section firstly as a whole and then breaks it down into its principal elements, i.e. toe, front slope, crest including decking, and the back face. There are also sections on hydraulic performance, design of slope protection, structural considerations, design for construction and a section on detailing of the various elements.

If one adds to this the exceptionally detailed information on the use and design of rock structures in the Rock Manual then the engineer has virtually a complete 'state of the art' available to him.

3.3.8 Environmental Assessment

Environmental assessment is comprehensively dealt with in both the Seawall Guidelines and the Rock Manual although the former deals primarily with UK practice.

3.3.9 Economic Appraisal

Economic appraisal and Benefit Cost Assessment in terms of UK practice and therefore NRA requirements, is best set out in the Seawall Guidelines. The Rock Manual takes a more broad view but does include for Dutch practice in this matter. As regards its relevance to rehabilitation much is, of course, appropriate but if there is a gap it is in the earlier 'trigger' stage leading up to the decision to continue repairs or consider rehabilitation and I have to review this in more detail. I need some guidance here with respect to the NRA division of responsibility between "Operations" and "New Works".

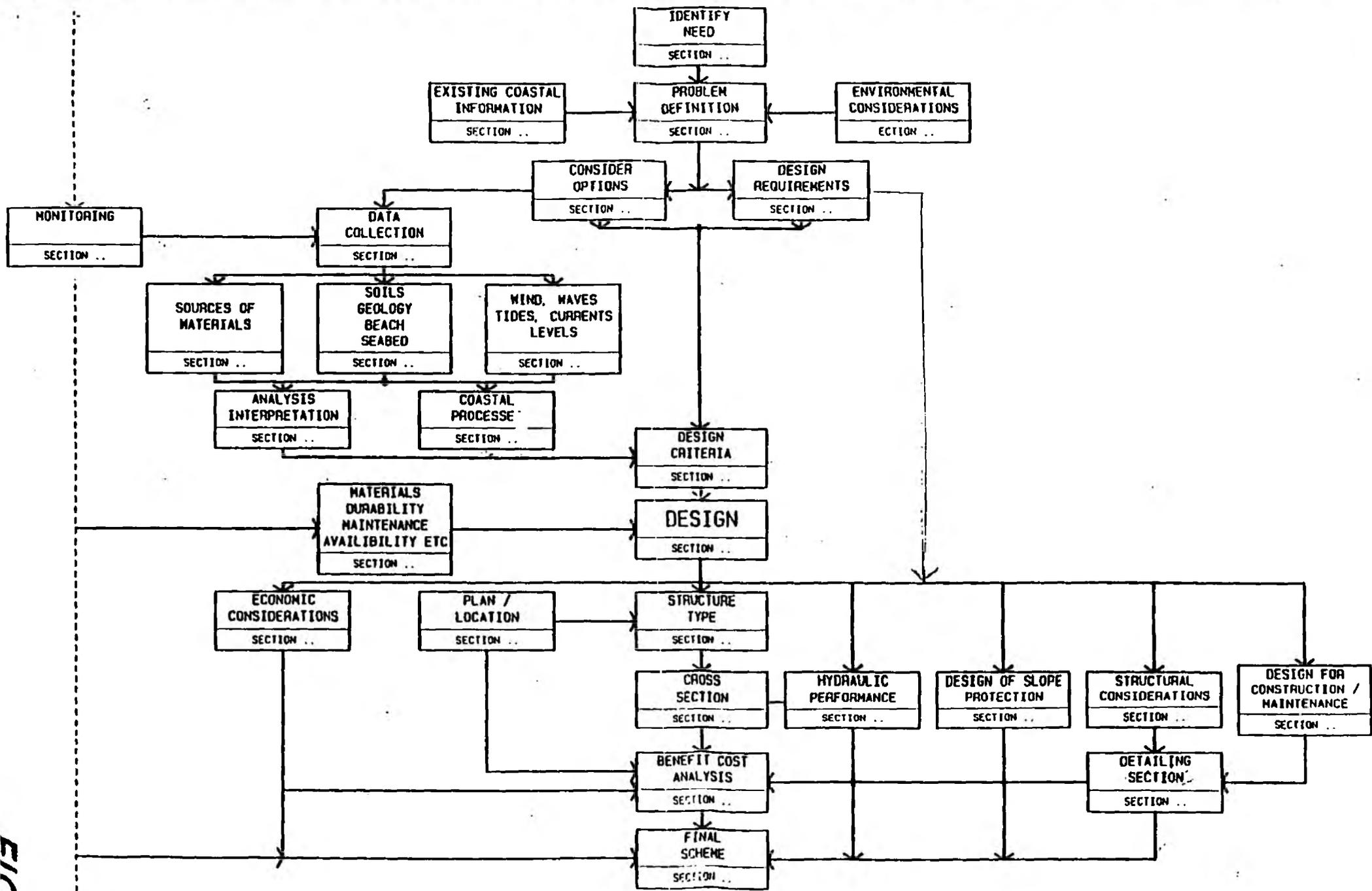


FIG. N:2

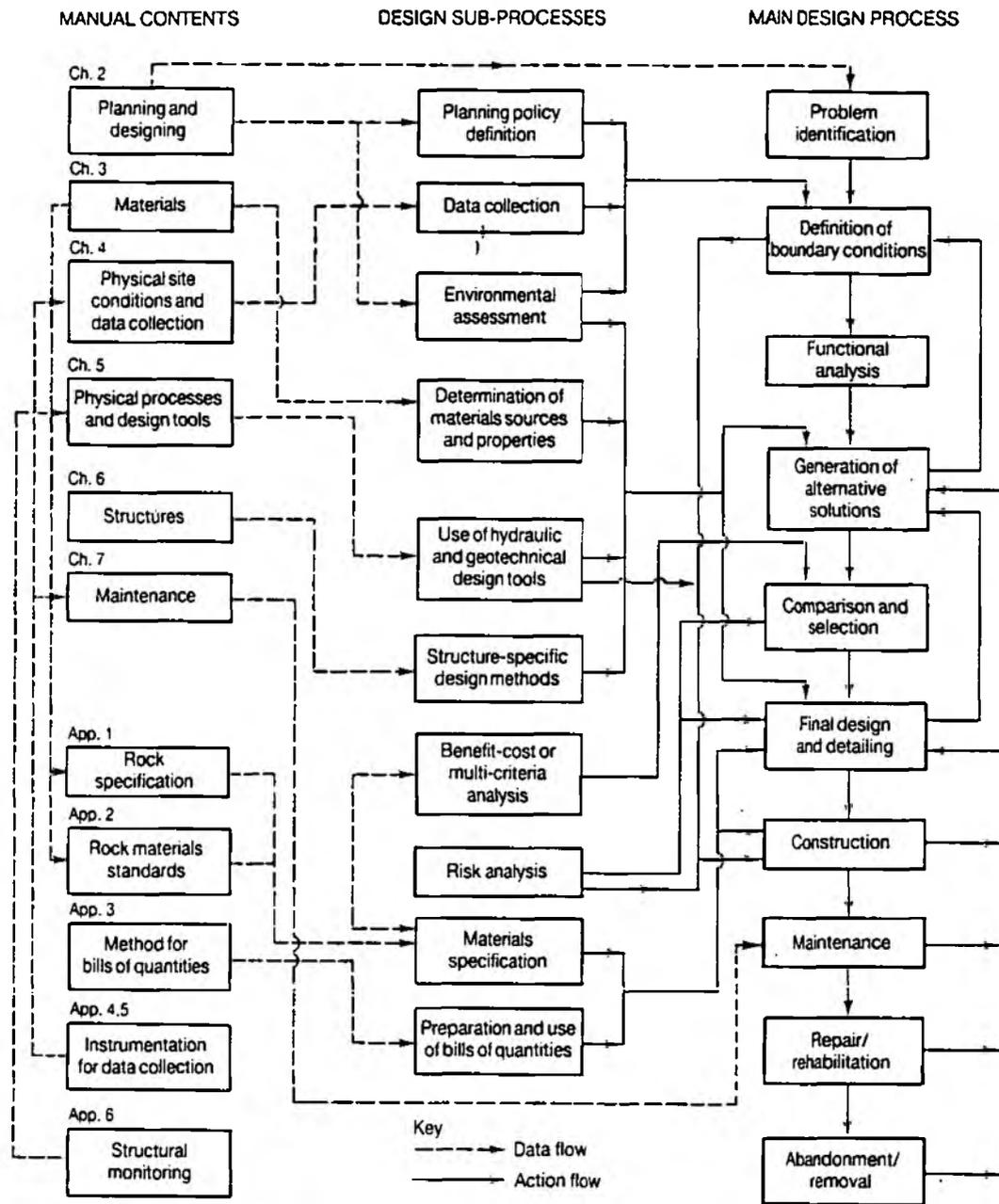


FIG. N°3.

3.3.10 Evaluation

Following on from the above is the question of "evaluation and decision making" and my first impression is that none of the documents under review deal very specifically with this subject. Having said that I do need to define more clearly what exactly might be needed.

3.3.11 Coastal Processes

The subject of coastal and physical processes is covered in considerable detail in both the Seawall Guidelines and the Rock Manual. The Seawall Guidelines is of most benefit as it gives names and addresses of data sources in the UK.

3.3.12 Design Criteria

In a similar vein the development of design criteria covering winds, waves, tides, surges and currents is again most adequately dealt with by the Seawall Guidelines and the Rock Manual.

3.3.13 Assessment of condition of structure

I have not seen in any of the documents a section devoted solely to this subject particularly from the point of view of determining the residual life of a structure but I need more time on this key section.

4.0 OVERALL PROGRESS

My review of the three main publications is substantially complete (say 75%). However I believe that I need to have a sight of the John Ash/Halcrow R & D Report on revetments to be sure about the question of overlap and other issues. To this end I have written to John Ash requesting a copy of the Final Draft which he gave me to understand would be available about now.

The remaining documents i.e. CIRIA Technical Notes 124 and 125 and the Shore Protection Manual are well known to me and will therefore need little review time.

I therefore anticipate completing the Literature Review on schedule by the end of April.

After that I will begin the work on the assessment of faults and solutions for different types of sea defence structures. This will necessitate access to the SDMS and NRA Seawall Survey results and I will start my enquiries on this next week.

Given that both Harry Lunt and myself have holiday commitments starting on 16th May I intend to submit a second progress report just prior to that date.

5.0 EXPENDITURE

The following table sets out the cost up to the date of Progress Meeting No. 1, the anticipated cost to Progress Meeting No. 2 (assumed as 14th May 1992) and shows the balance remaining to complete the Phase I work.

Item	Period	Staff	Travel	Report	Total
1	Total Project Costs	8400	700	100	9200
2	1st-31st March 1992 (Invoice No. 1)	4320	18	-	4338
	Balance	4080	682	100	4862
3	1st-14th April 1992	720	18	-	738
	Balance	3360	664	100	4121
4	Anticipated cost to next progress meeting (14th May 1992)	1440	50	-	1490
	Balance	£ 1920	614	100	2634

On the basis of the above I do not anticipate project costs being exceeded.

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10th April 1992