HR Wallingford

## ENGINEERING APPLICATIONS OF RESEARCH IN COHESIVE SEDIMENTS

Research Contract PECD 7/6/110
CONTRACT COMPLETION REPORT

## CONTRACT

This report describes work funded by the Department of the Environment under Research contract PECD $7 / 6 / 110$, for which the DoE nominated officer was Mr P Woodhead. It is published on behalf of the Department of the Environment, but any opinions expressed in the report are not necessarily those of the funding Department. The work was carried out at HR Wallingford in Dr E A Delo's Section of the Tidal Engineering Department, under the management of Mr M F C Thorn.
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This report describes the research carried out under contract PECD 7/6/110. The objectives of the research were:

1. To collaborate with university and polytechnic researchers carrying out research on cohesive sediments with other financial support, by providing $H R$ staff support, $H R$ experimental facilities and services.
2. To collate and interpret cohesive sediment research carried out by universities and polytechnics, collaboratively or otherwise, so as to make it available for practical engineering applications.

The contract enabled HR Wallingford to support seven university and polytechnic research projects in cohesive sediments. Each project has been described in a separate report; the abstract from each of these reports is included as an appendix.
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This contract commenced in 1987/88 and finished at the end of March 1991. It was jointly funded on a $50 / 50$ basis by the Department of the Environment and HR Wallingford.

The objectives of the contract were:

1. To collaborate with university and polytechnic researchers carrying out research on cohesive sediments with other financial support, by providing HR staff support, HR experimental facilities and services.
2. To collate and interpret cohesive sediment research carried out by universities and polytechnics, collaboratively or otherwise, so as to make it available for practical engineering applications.

## 2. COLLABORATIVE PROJECTS

The contract enabled HR Wallingford to support seven university and polytechnic research projects in cohesive sediments:

- Response of cohesive beds to fluid shear (Polytechnic South West)
- Cohesive sediment modelling (University of Liverpool)
- The transport of cohesive sediments in estuaries (University of Birmingham)
- Rheology of cohesive sediments under waves (University College Swansea)
- Inter-tidal zone cohesive sediment transport processes (University of Birmingham)
- Biogenic factors in the in-situ erodibility of sediments (University of Bristol)
- In-situ erodibility of cohesive sediments (University of Southampton)

The first two listed projects were undertaken and completed during this contract and the remaining five projects are on-going and being supported by another DoE/HR funded contract.

## Response of cohesive beds to fluid shear

Hydraulics Research worked in collaboration with the Department of Mathematics and Statistics (Dr T E R Jones and Dr P James) of Polytechnic South West on a SERC contract. Tests have been conducted in the HR carousel flume to measure the three components of the velocity field and used in calibration of a turbulence numerical model of the carousel flow set by the research assistant (Dr D Graham) of the Polytechnic. Flush mounted shear stress probes have been fitted into the HR carousel flume and tests have been completed to measure the bed shears. These have been compared with the results of the numerical model. Tests have been conducted on mud water systems in annular rheometers at Polytechnic Southwest. The contract was completed in November 1990.

This contract provided $H R$ and the research community with a proven flow model for the HR carousel flume. This enabled HR to improve the testing techniques for determining the engineering properties of cohesive sediments using the carousel flume. It also enhanced the general facilities at $H R$ in cohesive sediment experimentation which were available through the contract to researchers.

HR Wallingford produced a detailed report on the hydrodynamics of the carousel flume (HR Report SR 239) the abstract of which is presented in

Appendix A. A joint paper on the hydrodynamics of the carousel titled 'The prediction and measurement of bed shear stress in an annular flume' has been prepared for publication. The abstract of the paper is given in Appendix $B$.

## Cohesive sediment modelling

A collaborative project with Department of Civil Engineering (Prof. B A O'Connor) of Liverpool University on their SERC funded project on modelling of cohesive sediment processes has been undertaken. Laboratory tests have been conducted at Hydraulics Research to look at the erosion, entrainment, consolidation and settling properties of mud from Grangemouth Docks. A researcher from Liverpool University spent five weeks at Hydraulics Research conducting some of the laboratory tests. A report describing all the tests was produced (HR Report SR 197) and the abstract is presented in Appendix $C$.

A collaborative field survey exercise at Grangemouth was undertaken in which standard measurements of flow and suspended solids were obtained at six points on the Firth of Forth. Detailed monitoring of fluid mud development and movement was attempted using instruments mounted close to the bed on the submerged mud banks. The data was used in the calibration of the cohesive sediment transport models being developed by Liverpool University. A field investigation report was produced (HR Report SR 224) the abstract of which is given in Appendix D.

The collation of cohesive sediment research projects was undertaken by $H R$ as part of this contract. Initially, a questionnaire was circulated widely in the UK requesting information on active research projects in the field of cohesive sediments. The responses were collated into a report which was distributed throughout the UK and to a number of overseas researchers. The abstract and summary list of projects of this report (HR Report SR 217) are presented in Appendix E.

This exercise was extended to include Belgium, France and Japan one year later. A HR report was produced (HR Report SR 233) which was distributed to researchers throughout the world. The abstract and summary list of research projects are given in Appendix F .

The interpretation of cohesive sediment research and its dissemination for practical engineering applications was achieved by contributing to a oneday SERC seminar held at HR on 4 April 1989 on practical problems in cohesive sediments. The seminar was attended by 95 participants and the programme is given in Appendix $G$.

## 4. CONTINUING COLLABORATIVE PROJECTS

Five collaborative projects commenced during this contract and are on-going. A brief summary of these is presented below.

The transport of cohesive sediments in estuaries Collaborative work with the Department of Civil Engineering (Dr J R West) at Birmingham University on a SERC funded project commenced in Spring of
1990. The objectives of the project are to obtain field turbulence measurements in two estuaries, to conduct flume experiments at HR on muds from the estuaries, and to consider theoretical relationships for the erosion and entrainment of mud layers. The Parrett estuary has been selected as one site. This estuary was also studied in respect of fluid mud movements by HR in the Summer of 1989 . This will provide valuable experience and data to the SERC project. A field exercise is planned for the summer of 1991.

## Rheology of cohesive sediments under waves

 The Department of Chemical Engineering (Dr D J Williams) at University College Swansea was awarded a three year SERC grant to study the structural response of a cohesive sediment bed to wave action. A post-doctoral research assistant (Dr N Babotope) was appointed. An in-situ rheometer will be further developed and deployed in cohesive sediment beds in a wave flume at HR. From the tests a theory for predicting the structural response will be formulated and proved.
## Inter-tidal zone cohesive sediment transport processes

This is a SERC CASE Studentship with HR which commenced in October 1990. IT is looking at the mechanisms of erosion and deposition of cohesive sediment for estuarine inter-tidal zones using field, laboratory and mathematical modelling techniques. The SERC award is in the Department of Civil Engineering (Dr J R West) at Birmingham University. Visits to HR have been made by the research student (Mr D Freeman) and discussions have taken place with respect to field work planned for the summer of 1991.

## Biogenic factors in the in-situ erodibility of cohesive sediments <br> This is a NERC CASE Studentship with the Department of Botany (Dr D Paterson) at Bristol University. The topic is the study of in-situ erodibility of cohesive sediment with respect to the biological factors influencing its behaviour. The research student (Mr C George) has made four long visits to HR so far to measure the erosion of cohesive sediments using HR facilities.

## In-situ erodibility of cohesive sediments

Support has been given by HR to a SERC funded PhD student (Mr C Cowgill) of the Department of Civil Engineering at Southampton University who is developing an in-situ flume to measure the erosion shear strength of cohesive sediment in the intertidal zone.

This contract has succeeded by making available to researchers the facilities and experience of $H R$ and in so-doing has added value to a number of research projects in cohesive sediments. The collation and dissemination of research results by $H R$ through the database and the seminar were very well received by researchers and practical engineers.

The second phase of this work under the three year contract PECD 7/6/192 which commenced in April 1990 will support the on-going collaborative projects and include an updated version of the Estuarine Muds Manual.

APPENDICES.

APPENDIX A

Abstract of HR Report SR 239:
The Hydrodynamics of the Carousel
January 1990

A research programme has been undertaken by Hydraulics Research in conjunction with Polytechnic South West (PSW) to measure and predict the hydrodynamics of the HR Carousel flume. The project was funded jointly by the Science and Engineering Research Council, Hydraulics Research Limited and the Department of the Environment.

The aim of the work described in this report was (i) to measure the hydrodynamics of the Carousel, (ii) to apply the HARWELL-FLOW3D mathematical model to the flow in the Carousel, and (iii) to compare shear stress results derived from the Carousel and the mathematical model.

This successful study has increased the breadth and depth of knowledge of the hydrodynamics of the Carousel which has improved the reputation of the Carousel as a major and unique UK research facility. The study has enabled the Carousel to be more widely used for engineering research on cohesive sediments both by Hydraulics Research and by other UK research institutions.

The accuracy and scope of the engineering tests on cohesive sediment samples from sites around the world which are carried out by Hydraulics Research in the Carousel have been improved by the results of this study. The ability to predict the movement of cohesive sediment within coastal, estuarine or inland waters has a significant economical and ecological importance in the development of new engineering works and the maintenance of existing installations. The future viability of a proposed new port, for example, could largely depend on the cost of routine dredging necessary to sustain its accessibility to shipping. Many other schemes, such as the reclamation of intertidal flats, or the construction of flood protection structures or the laying of outfalls, also require a sound engineering appraisal of the likely changes in the patterns of sediment movement which will result after the scheme is built. Furthermore, the capability to predict the movement of cohesive sediment is crucial in the understanding of the distribution of certain pollutants, in particular heavy metals which are adsorbed on to clay and silt particles.

As yet, it is not possible to predict the behaviour of a cohesive sediment from its physical and chemical properties alone and the principal thrust of research has been to determine in the laboratory, for a given set of flow conditions, the behaviour of a sample of the cohesive sediment taken from the field.

The Carousel flume is an annular flume, with an outer diameter of 6 m , a channel width of 0.4 m and depth of 0.35 m , and has a detachable roof 0.09 m thick. The flume stands approximately 1.1 m off the ground, supported by 12 brick pillars. The channel and the roof are constructed of fibre glass, with a 0.12 m long perspex section in the channel for viewing. The roof fits into the channel, and floats on the fluid. Fluid motion in the Carousel flume is induced and continued by the drag between the roof and the fluid surface as the roof rotates.

Experiments were undertaken to measure all three velocity components (circumferential, vertical and radial) of the flow within the Carousel. PSW has applied the HARWELL-FLOW3D package to numerically model the turbulent flow of clean water in the Carousel. This data was compared with velocity
measurements within the flume and found to give good agreement for the primary flow field.

A new method of measuring bed shear stress in the Carousel was deployed using flush mounted hot wire anemometry probes. All stress measurements were made in clean water. The data retrieved by the shear stress probes was compared with shear stress data from the HARWELL-FLOW3D model and the correlation was found to be good.

The measured and predicted shear stress data was also compared with the depths of erosion across the width of the Carousel flume for a number of muds previously tested by Hydraulics Research. This indicated that the depths of erosion of the cohesive sediments closely reflected the applied bed shear stress within the Carousel.

The shear stress probes have not yet been used with cohesive sediment suspensions as they would be very susceptible to surface damage without a secondary polymer coating.

APPENDIX B

Abstract of HR/South West Polytechnic joint paper:
The Prediction and Measurement of Bed Shear Stress in an Annular Flume

# THE PREDICTION AND MEASUREMENT OF BED SHEAR STRESS IN AN ANNULAR FLUME 

by
D.I.Graham, P.W.James, T.E.R.Jones, J.M.Davies and E.A.Delo ${ }^{1}$ Polytechnic South West, Drake Circus, Plymouth, Devon, England, PL4 8AA


#### Abstract

Cohesive sediment beds occur in a variety of natural and man-made environments, for example in harbours, marinas and estuaries. A knowledge of the way in which such beds move when acted on by anerlying flow is essential for the design, construction and control of these environments. A parameter which has a very significant influence on the sediment behaviour is the critical bed shear stress for erosion. This is the shear stress at the sediment surface above which erosion will take place. The critical shear stress can be evaluated in the laboratory under conditions closely resembling those found in the field by use of an annular flume. The main purpose of the work described in this paper is to investigate experimentally and theoretically the flow of water in an annular flume. Very good agreement is found between measured circumferential velocity profiles, obtained by laser doppler anemometry, and profiles predicted by the computational fluid dynamics program HARWELL-FLOW3D. Measurements of the bed and wall shear stresses are made using hot-film probes and these too agree reasonably well with theoretical predictions.

Another parameter of importance is the sediment shear strength and its dependence on sediment depth. By comparing eroded sediment contours with predicted shear stress profiles a simple method emerges for predicting this dependence. Finally, a brief look is taken at the way in which simple modifications to the flume cross-section affect the prediction of bed shear stress. An assessment can then be made of the sensitivity of bed shear stress predictions to non-uniform beds.


[^0]APPENDIX C

Abstract of HR Report SR 197:
Grangemouth Mud Properties
February 1989


#### Abstract

Hydraulics Research (HR) and the Department of the Environment (DoE) have jointly funded research with the objective of collaborating with University and Polytechnic researchers in the field of cohesive sediments. One such collaboration was undertaken with the Department of Civil Engineering at Liverpool University, which received a two year grant from the Science and Engineering Council commencing October 1988, to study mud process modelling. Hydraulics Research had committed to provide support for this research by assisting in the testing of mud from the site at which the mud process modelling was to be investigated. Assistance was also to be given in the execution of a field survey at the site. The site chosen for the study was Grangemouth on the Firth of Forth, Scotland.

An investigation of the properties of Grangemouth mud was undertaken at Hydraulics Research by HR staff and a visiting research assistant from Liverpool University. The study comprised standard mud tests to measure the consolidation and erosion properties and new investigative techniques to determine the likely importance of other cohesive sediment transport processes.


New techniques were used to study the settling of cohesive sediment on slopes and the entrainment of fluid mud by flowing water. Both of these processes were postulated as being important in the transport mechanisms at Grangemouth. An attempt will be made to observe these processes in the field during the forthcoming survey exercise at Grangemouth. The results of the laboratory studies described in this report and the field measurements will be used in the development of a three dimensional mud transport numerical model at Liverpool University.

Sedimentology tests were undertaken to determine particle size distribution, organic content, bulk density and cation exchange capacity of the mud. Standard laboratory tests were run to determine the consolidation and erosion properties of the mud. Six consolidation tests were conducted in settling columns and empirical relationships between effective stress and dry density and between permeability and dry density were determined. Three erosion tests were conducted in the carousel flume from which an empirical relationship between erosion shear strength and dry density was found and an estimated value of the erosion constant.

New laboratory techniques were employed to study the process of deposition of sediment on slopes and the entrainment of fluid mud in flowing water. A researcher from Liverpool University conducted tests in a small tilting flume at Hydraulics Research to investigate the deposition of mud on slopes. Two mechanisms for movement of the mud down the slope were identified. The first was "density flow", which was thought to be dependent on the occurrence of hindered settling (for which the near-bed concentration needed to exceed approximately $10 \mathrm{gl}^{-1}$ ). The second mechanism was "bed slump", which occurred if a weak matrix of flocculated sediment, forming on the bed, exceeded a critical thickness. The critical thickness was found to be dependent on the bed slope. Re-entrainment of the moving bed layer into the overlying suspension and erosion of the underlying mud bed, by the moving bed layer, were not observed in the experiments. Bed slump was considered to be the main mechanism for down the slope transport of mud.

Tests were conducted in the carousel flume to investigate the entrainment fluid mud by flowing water. It was intended to examine the importance of the bulk Richardson number in determining the critical conditions for entrainment. However, it was found to be generally difficult to generate the carousel the desired initial conditions of a fluid mud layer beneath a overlying less concentrated suspension. Nevertheless, instabilities were seen in the form of interfacial waves between the fluid mud and overlying flowing suspension in some of the tests.

## APPENDIX D

Abstract of HR Report SR 224:
Grangemouth Fluid Mud Study: Field Investigation June 1990


#### Abstract

Hydraulics Research (HR) and the Department of the Environment (DoE) have jointly funded research with the objective of collaborating with University and Polytechnic researchers in the field of cohesive sediments. one such collaboration was undertaken with the Department of Civil Engineering at Liverpool University, which received a grant from the Science and Engineering Council commencing October 1988, to study mud process modelling. Hydraulics Research had committed to provide support for this research by assisting in the execution of a field survey at the site at which the mud process modelling was to be investigated. Assistance was also given in the testing of mud from the site (Ref 1). The site chosen for the study was Grangemouth on the Firth of Forth, Scotland.

An intensive programme of field measurements was undertaken at the site by staff from HR and Liverpool University in close collaboration with the Forth Ports Authority who provided the necessary survey vessels. The programme comprised standard anchored vessel measurements and measurements of suspended solids concentrations at six positions in the vicinity of Grangemouth Harbour to gain an insight into patterns of water and silt movement during the tidal cycle. A new investigation technique was implemented to measure the movement of fluid mud.

During the field survey new techniques were used in order to attempt to observe the settling of cohesive sediment on bed slopes and the entrainment of fluid mud by flowing water. Both of these processes were postulated as being important in the transport mechanisms at Grangemouth. The results of the studies described in this report and the results of earlier laboratory investigations (Ref 1) will be used in the development of a three dimensional mud transport numerical model at Liverpool University.

Anchored vessel measurements were made during a period when the tidal range at Grangemouth was mid way between that of a mean spring and a mean neap range. At each of the six monitoring positions, measurements of tidal flow components were made for a full tidal cycle (approximately 12.5 hours). Information collected during this exercise will be used to create a calibration data base for the numerical model.

In addition to the above tidal measurements, sensors installed at the entrance to Grangemouth Dock recorded suspended solids concentrations during the entire duration of the field survey. This information was to be predominantly used by $H R$ in the developing of a dredging experiment in order to determine siltation rates at ship berths.

A new measurement technique was employed in an attempt to record the movement of fluid mud on the intertidal banks and in the harbour bellmouth. The instrument used was a 'Sonatest' oscilloscope and echo sounder transducer. With the small transducer fixed to a purpose built bed frame it was possible to measure bed levels to an accuracy of better than 0.1 mm . An additional capability of the instrument is that it can "see" through the bed, depending on the density of the material, up to a depth of several centimetres.


Detection of the bed and its underlying layers are displayed on the oscilloscope by spikes of variable amplitude, the amplitude depending on the density of the material and the position of the detected bed relative to the transducer. During the observations the bed level was seen to change by up to 50 mm during a tidal cycle, there being definite phases of erosion and deposition. It was also considered that a layer of fluid mud about 5 mm thick was observed late during an ebb tide to be flowing down a steep bank into the harbour bellmouth.

In all it was considered that the technique had substantial potential and that the measurement system could provide considerable insight into physical processes in any similar field study.

## APPENDIX E

Abstract and summary list of projects of HR Report SR 217:

Cohesive Sediment Research: A database of UK
Projects
March 1989

ABSTRACT

Hydraulics Research (HR) and the Department of the Environment (DoE) have jointly funded research with the objective of collaborating with University and Polytechnic researchers in the field of cohesive sediments.

To ensure that $H R$ were fully aware of ongoing and recent past research on cohesive sediments in the UK, a questionnaire was circulated in a letter dated 29 November 1988 to many researchers at UK institutions. Information was requested on project timing, funding organisation, scope of work, progress and publications to date. The returned completed forms were collated and distributed to respondents and other interested parties.

This report comprises the completed questionnaire forms and a one page summary of projects.
COHESIVE SEDIMENTS RESEARCH


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| investigator | Institution | Title | Sponsor (s) |
| :---: | :---: | :---: | :---: |
| sills 6 c | University of Oxford | Sediment behaviour in the lrish Sea | DoE / MAFF |
| sills G C | University of Oxford | Properties of surface layers of sediment beds | SERC |
| Burt T N | Hydraulics Research | Estuarine muds | DOE (CID) |
| Odd NVMO | Hydraulics Research | Fluid mud processes | DOE (CID) |
| Burt T N | Hydraulics Research | Siltation and stability of dredged channels | DOE (CID) |
| Delo EA | Hydraulics Research | Engineering application of academic research in cohesive sediments | DOE (CID) |
| Evans EM | IMS Plymouth Polytechnic | Modelling cohesive sediment transport | WRe |
| Hebber N B | University of Southampton | Field investigation of siltation | SERC |
| Jones T E R | Plymouth Polytechnic | Response of cohesive beds to fluid shear | SERC / HR |
| Dyer KR | IMS Plymouth Polytechnic | The interaction of suspended cohesive sediments with turbulent flow | NERC / PML |
| Alani S | IMS Plymouth Polytechnic | The strength, density and settling velocity of cohesive flocs | NERC |
| Hardman TM | University of Reading | Physical chemistry of cohesive sediments | SERC |
| Delo EA | Hydraulics Research | Fluidisation of settled mud by wave action | DOE (CID) |
| Dyer K R | IMS Plymouth Polytechnic | Residence time and cycling of particles within a turbidity maximum | nerc (Case) |
| óConnor B A | University of Liverpool | mud process modelling | SERC / HR |
| Paterson D M | University of Bristol | Biogenic stabilisation of estuarine tidal flats | RS |
| sills G C | University of Oxford | Consolidation of phosphatic muds | ? |
| falconer | University of 8radford | Mathematical modelling of flow and solute and sediment transport | ECSTC, China |
| Odd N V M O | Hydraulics Research | Extrapolating tidal model predictions to long term siltation effects | DOE (CID) |
| Burt T N | Hydraulics Research | flocculation of cohesive sediment | DOE (CID) |
| Delo E A | Hydraulics Research | Estuarine sediments: near-bed processes | DOE (CID) |
| Odd NVM O | Hydraulics Research | fluid mud processes | ETSU |
| McCave : N | University of Cambridge | North East Coast Cohesive Sediment Dynamics Study (NECCESEDS) | DOE / MAFF |
| vincent CE | University of East Anglia | North East Coast Cohesive Sediment Dynamics Study (NECCESEDS) | DOE / MAFF |
| Dickson R R | MAFF Lowestoft | North East Coast Cohesive Sediment Dynamics Study (NECCESEDS) | DOE / MAFF |

## APPENDIX F

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Abstract and summary list of projects of HR Report
SR 233:
Cohesive Sediment Research: A database of projects
in the UK, Belgium, France and Japan
March }199
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## ABSTRACT

Hydraulics Research (HR) and the Department of the Environment (DoE) have jointly funded research with the objective of HR collaborating with University and Polytechnic researchers in the field of cohesive sediments.

To ensure that $H R$ were fully aware of on-going and recent past research on cohesive sediments in the UK, a database of projects was collated and published in March 1989 (HR Report SR 217). A request for information of projects was then sent during 1989 to researchers in Belgium, France, USA, Japan and Holland with the assistance of Dr Reg Parker (USA and Japan) and Professor Brian $0^{\prime}$ Connor (Holland). In addition, the UK researchers were requested to up-date their information in late 1989.

This report comprises the completed questionnaire forms received from researchers in the UK, Belgium, France and Japan together with summary lists of the projects. Unfortunately, no replies were obtained from the USA or Holland.

| Sponsor(s) | Start | Finish |
| :---: | :---: | :---: |
| SERC | 01-Feb-90 | 01-Jan-92 |
| EC/S\&T Comm | 01-Jan-90 | 31-Dec-92 |
| UKAEA | 01-Dec-89 | 01-Jun-91 |
| MOD | 01-0ct-89 | 30-Sep-92 |
| ETSU | 01-May-89 | 31-Jan-91 |
| DOE (CID) | 01-Apr-89 | 31-Mar-92 |
| SERC | 01-Mar-89 | 30-Sep-92 |
| DOE (CID) | 01-Apr-89 | 31-Mar-92 |
| ETSU | 01-Apr-89 | 31 Mar-90 |
| - | 01-Jan-89 | 30-Sep-89 |
| NERC/Govt of Rep China | 1989 | 1992+ |
| Royal Society | 01-Dec-88 | 01-Dec-93 |
| SERC/HR | 01-0ct-88 | 30-Sep-90 |

COHESIVE SEDIMENTS RESEARCH

|  |  | UK |
| :---: | :---: | :---: |
| COHESIVE SEDIMENTS RESEARCH |  |  |
| Investigator | Institution | Title |
| West JR | University of Birmingham | The transport of cohesive sediments in estuaries |
| Falconer | University of Bradford | Mathematical modelling of flow and solute and sediment transport in coastal waters, Estuaries and Rivers |
| Little C | University of Bristol | Algal stabilistion of estuarine sediments |
| West J R | University of Birmingham | Solute and sediment transport in the Forth Estuary |
| Odd N V M | Hydraulics Research | Fluid mud in estuaries |
| Delo E A | Hydraulics Research | Estuarine sediments - near-bed processes |
| West J R | University of Birmingham | Long term inter-tidal zone cohesive sediment transport processes |
| T N Burt | Hydraulics Research | Flocculation of cohesive sediment |
| Odd NVM | Hydraulics Research | A review of methods of extrapolating tidal model predictions to long term siltation effects in estuaries |
| Sills GC | Oxford University | Consolidation of phosphatic muds |
| Collins U B | University of Southampton | Various projects as studentships |
| Paterson D M | University of Bristol | Biogenic stabilisation of estuarine tidal flats |
| $O^{\prime}$ Connor B A | Liverpool University | Mud process modelling |

[^1]COHESIVE SEDIMENTS RESEARCH
Investigator Institution
Marsh J Plymouth Polytechnic

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DOE (CID)
DoE/MAFF
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31-Jan-90
30-Sep-90
30-Sep-90
30-Sep-90

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| -1 | 0 |
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| Start | Finish |
| :--- | :--- |
| 01-Apr-87 | 31-Mar-90 |
| 01-Apr-86 | 31-Mar-88 |
| 01-Apr-85 | 31-Mar-88 |
| 01-Apr-85 | 31-Mar-88 |
| 01-Mar-85 | 31-Aug-88 |
| 01-Oct-83 | 31-Mar-88 |

Sponsor(s)
DOE (CID)
DOE (CID)
DOE (CID)
DOE (CID)
SERC
DOE/MAFF

## (p,7400) <br> $-\bar{x}$

Title

| Engineering application of academic research |
| :--- |
| in cohesive sediments |

Siltation and stability of dredged channels
Fluid mud processes
Estuarine muds
Properties of surface layers of sediment beds
Sediment behaviour in the Irish Sea

| Sponsor (s) | Start | Finish |
| :---: | :---: | :---: |
| IMDC/ | 1988 | 1990 |
| K U Leuven |  |  |
| K U Leuven 1988 |  |  |
|  |  |  |
| Min of Public 01-Jan-86Works/Haecke |  | 31-Dec-90 |
|  |  |  |
| \& Van der |  |  |
| Meerssche/ |  |  |
| Dredging Int |  |  |
| Min of Public 1984 |  | - |
| Works |  |  |
| Min of Public | 1984 | - |
| Works |  |  |

Title
Consolidation of layered mud
F E model for fluid mud flow towards pumping wells
Improvement of the efficiency of agitation dredging

[^2]
## COHESIVE SEDIMENTS RESEARCH

Investigator Institution
Bosch L van K U Leuven
Den
Toorman E K U Leuven
de Laet $P$ Waterbouwkundig Labora-
torium Borgernout/
Min of Public Works/
Waterbouwkundig Labora-
torium Borgerhout/
Min of Public Works
Determination of nautical bottom in muddy areas
BELGIUM

BELGIUM

| Start | Finish |
| :--- | :--- |
| 1989 | 1993 |
| 1988 | $1992 \ldots$ |
| 1987 | 1990 |
| $01-J a n-86$ | $31-$ Dec-88 |

Sponsor(s)
IFREMER
IFREMER
IFREMER
EDF/STC
Title
Mathematical modelling of fluid mud and turbidity
maximum in the Loire estuary
General study of cohesive sediment processes
Mathematical modelling of cohesive sediment
Morlaix estuary
Numerical modelling of suspended sediment transport
Fritsch D Laboratoire National
COHESIVE SEDIMENTS RESEARCH
Investigator Institution
le Hir $p$ IFREMER
Bassoullet $P$ IFREMER
le Hir $p$ IFREMER
Fritsch $D \quad$ Laboratoire National
d'Hydraulique

| Sponsor(s) | Start | Finish |
| :---: | :---: | :---: |
| Grant-in-Aid for SR/Min of Education | 01-Apr-89 | 31-Mar-90 |
| TOA Corp | 01-Apr-88 | 31-Mar-90 |
| Univ of Tokushima/ Grant-in-Aid for SR/Min of Education | 01-Apr-88 | 31-Mar-90 |
| Min of Transport | 01-Apr-88 | 31-Mar-90 |
| - | 01-Apr-87 | 31-Mar-90 |
| TOA Corp | 01-Apr-87 | 31-Mar-91 |
| TOA Corp | 01-Apr-85 | 31-Mar-88 |
| Min of Transport | 01-Apr-85 | 31-Mar-89 |
| Min of Education/ <br> Ibaraki Univ | 01-Apr-85 | 31-Mar-87 |

COHESIVE SEDIMENTS RESEARCH
Investigator Institution
Watanabe A University of Tokyo
Yauchi E TOA Corporation
Nakano S Univ of Tokushima
$\begin{array}{cl}\text { Murakami K } \begin{array}{l}\text { Port \& Harbour Research } \\ \text { Institute, Min of }\end{array} \\ & \text { Iransar }\end{array}$
Numerical simulation of mud transport
squading pue sanem to uo!foe pau!quos a47
The diffusion of a mud lump falling
Interaction between waves and soft mud in a
uniform current

The diffusion of a mud lump falling
uniform current

Sand covering method for seabed mud under waves
Mud behaviour and wave damping under progressive
waves
Study on erosion and deposition of fine cohesive
sediment in a tidal flow
Flocculation of clay and natural mud, and floc
settling

| Start | Finish |
| :--- | :--- |
| 01-Apr-85 | 31-Mar-89 |
| 01-Apr-84 | 31-Dec-88 |
| 1974 | 1982 |

Sponsor(s)
Japanese
Government
1
Title
Determination of yield stress of soft muds with
vane and slump test
Field measurement of settiing flux of fine organic
particles to bottom inner bay
Erosion and stream formation on a cohesive
JAPAN (Cont'd)

APPENDIX G

Programme of one day Seminar:
SERC Initiative in Cohesive Sediments: Some
practical problems and how to solve them
4 April 1989

# SERC INITIATIVE IN COHESIVE SEDIMENTS 

## SOME PRACTICAL PROBLEMS AND HOW TO SOLVE THEM

One Day Seminar, Tuesday 4 April 1989
Hydraulics Research Ltd, Wallingford, Oxon, OX10 8BA

## PROGRAMME

Session 1 - The problems and how to tackle them
Chairman : Professor D.M. McDowell

| $10.00-10.30$ | Arrival and coffee |
| :--- | :--- |
| $10.30-10.40$ | Introduction |
|  | (Professor D.M. McDowell) |

10.40-11.05 Some problems with marine cohesive sediments
(Mr A.A.C. Baker, Divisional Director, Binnie \& Partners)
11.05-11.30 Some field and laboratory studies of marine sediments (Dr E.A. Delo, Hydraulics Research Ltd)
11.30-12.05 Some problems with sewer sediments (Dr R.W. Crabtree, Water Research Centre)
12.05-12.30 The SERC initiative (Dr W.R. Parker, Blackdown Consultants)
12.30-12.45 Discussion

Session 2 - The answers and how to obtain them
Chairman: Mr G. Thompson (Binnie \& Partners)
14.00-14.25 Laboratory and field tests
(Dr G.C. Sills, Oxford University)
14.25-14.50 Rheological Tests
(Dr P.W. James, Plymouth Polytechnic)
14.50-15.15 Modelling of cohesive sediments
(Professor B.A. O'Connor, Liverpool University)
15.15-15.40 Modelling of radionuclides
(Dr P.A. Gurbutt, MAFF, Lowestoft)
15.40-16.00 Discussion
$16.00-16.30$ Tea

Cost: £20

| For further details contact: | Dr Donald W. Knight, SERC Programme Coordinator <br> Civil Engineering Department, University of Birmingham |
| :--- | :--- |
|  | P.O. Box 363 B 15 2TT $(021-414-5075 / 5049)$ |


[^0]:    'Hydraulics Research, Wallingford, Oxon, England, 0x10 8BA

[^1]:    Biogenic stabilisation of estuarine tidal flats
    Mud process modelling

[^2]:    Determination of nautical bottom in muddy areas
    Determination of nautical depth in muddy areas
    

