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The structure of flow in open channels - a literature search

Volume 4

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SUMMARY

This report presents the result of a literature search into flow in open channels with particular interest in Flood Channels.

The search is presented in the form of three files:

- a card index file developed on the Apricot micro computer associated with the Flood Channel Facility which indicates the source of the publication and gives details of any experimental facility.

- a precis of each paper or book accessed indicating the channel type studied, the aims of the paper, conclusions drawn and the nature of the instruments used in the study.

- details of the channels studied in previous research into flow interaction, secondary flow, turbulence, momentum transfer etc, unified in S.1 units. Three relevant dimensionless parameters are also presented.

This report supplements The structure of flow in open channels - a literature search, January 1987, January 1988 and June 1989.

The layout of the contents of this report are the same as for Report Nos SR 96, SR 153 and SR 209.

CONTENTS

1 ACKNOWLEDGEMENTS

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The author carried out the work in Dr P G Samuels section in the River Engineering Department at Hydraulics Research, headed by Dr W R White.

The author is grateful to Dr D A Ervine of Glasgow University, Dr D W Knight of Birmingham University, Dr W R C Myers of Ulster University, Dr R H J Sellin of Bristol University, Dr P R Wormleaton of Queen Mary College, London University and Professor B B Willetts of Aberdeen University for their help in compiling the references in the literature search.

2 CARD INDEX OF PAPERS

The card index was compiled on the Apricot Xi-10 micro computer associated with the Flood Channel Facility at Hydraulics Research, using CARDBOX-PLUS, Version 3 as supplied by Business Simulations Ltd.

The field captions used in the card index are detailed below:

Author	self explanatory
Title	self explanatory
Pub'n	publication (see Abbreviation of Publications)
Data	form of data presentation, graphical notation
Key words	self explanatory
Channel type	channel types are defined as experimental, prototypical, theoretical, simple, compound, smooth, rough, bend, duct or pipe. Due to the restricted space available on the card format used, abbreviations of the above channel descriptions are frequently necessary.
FL, FW, FD	flume length, width and depth
CL, CW, CD	channel length, width and depth
FCS	flume or channel slope, eg 2(-3) represents a slope of 0.002
Q	discharge
INST	instruments used in experimental work

Abbreviation of Publications

AMER	American
ANN	Annual
ASME	American Society of Mechanical Engineers
ASP	Aspects
CH, CHAN	Channel
CIV	Civil
CONF	Conference
CONG	Congress
CONST	Construction
CONT	Control
DEPT	Department
D, DIV	Division
DPRI	Disaster Prevention Research Institute
ELEM	Elements
EM	Engineering Mechanics
ENG	Engineering
EXP	Experimental
FIN	Finite
FOUND	Foundation
GEOL	Geological
GEOPHYS	Geophysical
HYD, HYDR	Hydraulics
IAHR	International Association Hydraulic Research
ID	Irrigation and Drainage
IHW	Institut for Hydromechanik and Wasserwirtschaft
INST	Institute
INT	International

IWES	Institute of Water Engineers and Scientists
J	Journal
JICE	Journal Institute of Civil Engineers
JSCE	Japan Society of Civil Engineers
MEAS	Measurements
MECH	Mechanics
MIN	Ministry
MOD	Modelling
NACA	National Advisory Committee for Aeronautics
NO	Number
PASCE	Proceedings American Society of Civil Engineers
PICE	Proceedings Institute of Civil Engineers
PROC	Proceedings
REF	Refined
REG	Regional
RES	Research
REV	Review
SED	Sediment
SOC	Society
STN	Station
STR	Structures
SYMP	Symposium
TASCE	Transactions American Society of Civil Engineers
TASME	Transactions American Society of Mechanical Engineers
TECH	Technical
TN	Technical note

TRANS	Transactions
TUR	Turbulence
UKAEA	United Kingdom Atomic Energy Authority
UNIV	University
US	United States
USWES	United States Waterways Experimental Station
VOL	Volume
WH, WAT, HAR	Waterways and Harbours

A copy of each of the papers detailed in the card index is kept on the Flood Channel Facility. Books referred to are kept in the library at Hydraulics Research Ltd. The author accepts that the literature search does not give a comprehensive coverage of papers and books relating to the structure of flow in open channels. The literature search will be updated as further material becomes available in recognition of this fact.

AUTHOR ARNOLD U, ROUVE G, STEIN G	PUB'N HYDROCOMP 89, DUBROVNIK, YUGOSLAVIA, JUNE, 1989
TITLE A REVIEW OF INVESTIGATIONS ON COMPOUND OPEN CHANNEL FLOW	
DATA EXPERIMENTAL STUDIES, ANALYTICAL STUDIES, NUMERICAL MODELING	KEY WORDS REVIEW, COMPOUND CHANNELS, SECONDARY CURRENTS, RESISTANCE, TURBULENCE
CHANNEL TYPE THRY, EXP, PROTO, COMP, SMTH, RGH	

FL	FW	FD
CL	CW	CD
FCS	Q	INST

AUTHOR ARNOLD U, STEIN J, ROUVE G	PUB'N HYDROCOMP 89, DUBROVNIK, YUGOSLAVIA, JUNE, 1989
TITLE SOPHISTICATED MEASUREMENT TECHNIQUES FOR EXPERIMENTAL INVESTIGATION OF COMPOUND OPEN CHANNEL FLOW	
DATA VELOCITY, REYNOLDS STRESS	KEY WORDS COMPOUND CHANNEL, LASER DOPPLER ANEMOMETER, MEASUREMENT TECHNIQUES
CHANNEL TYPE EXP, COMP, SMOOTH, ROUGH	

FL	FW	FD
CL	CW	CD
FCS	Q	INST

AUTHOR ARNOLD U, PASCHE E, ROUVE G	PUB'N 21ST IAHR CONGRESS, VOL 2, MELBOURNE, 1985
TITLE MIXING IN RIVERS WITH COMPOUND CROSS SECTION	
DATA TRANSVERSE DISPERSION COEFFICIENT, TRANSVERSE DISPERSION COEFFICIENT, CONCENTRATION DISTRIBUTION	KEY WORDS COMPOUND CHANNEL, DIFFUSION, DISPERSION
CHANNEL TYPE EXP, THRY, COMP, SMTH, RGH	

FL 25 M	FW 1 M	FD
CL 25 M	CW 0.314, 0.489 M	CD 0.124 M
FCS	Q	INST LASER DOPPLER VELOCIMETER, TRACER, DIGITAL IMAGE PROCESSING

AUTHOR ARNOLD U, HOTTGES J, ROUVE G	PUB'N 23RD CONGRESS, IAHR, OTTAWA, AUGUST,1989
TITLE TURBULENCE AND MIXING MECHANISMS IN COMPOUND OPEN CHANNEL FLOW	
DATA VELOCITY COMPONENTS, REYNOLDS STRESS, TURBULENCE PARAMETER, TURBULENT SCHMIDT NO.	KEY WORDS COMPOUND CHANNEL, TURBULENCE, MIXING
CHANNEL TYPE EXP, THRY, COMP, SMTH, RGH	

FL 25 M	FW 1 M	FD
CL	CW	CD
FCS	Q	INST LASER DOPPLER ANEMOMETER

AUTHOR AUTRET A, GRANDOTTO M	PUB'N INT. J. FOR NUMERICAL METHODS IN FLUIDS, VOL 8, 1988
TITLE FINITE ELEMENT COMPUTATION OF A TURBULENT FLOW OVER A TWO DIMENSIONAL BACKWARD FACING STEP	
DATA STEP HEIGHT, CHAINAGE, VELOCITY PROFILE, TURBULENT KINETIC ENERGY, PRESSURE FIELD	KEY WORDS k-e TURBULENCE MODEL, FINITE ELEMENT METHOD, PENALTY FUNCTION APPROACH, WALL LAW
CHANNEL TYPE THRY, EXP, SIMP, SMTH, STEP	

FL	FW	FD
CL	CW	CD
FCS	Q	INST

AUTHOR BERBEE J G, ELLZEY J L	PUB'N EXPERIMENTS IN FLUIDS, 7, 1989
TITLE THE EFFECT OF ASPECT RATIO ON THE FLOW OVER A REARWARD FACING STEP	
DATA ASPECT RATIO, VELOCITY, TURBULENCE INTENSITY, STROUHAL NO., VELOCITY SPECTRA	KEY WORDS ASPECT RATIO, TURBULENCE
CHANNEL TYPE EXP, SIMP, SMTH, DUCT	

FL 0.35 M	FW 0.1016, 0.254 M	FD 0.075 M
CL 0.35 M	CW 0.1016 , 0.254 M	CD 0.075 M
FCS	Q AIR	INST LASER DOPPLER VELOCIMETER

.AUTHOR BOOIJ R .PUB'N 23RD CONGRESS, IAHR, OTTAWA, IAHR, 1989

.TITLE DEPTH AVERAGED k-e MODELLING

.DATA MIXING LAYER

.KEY WORDS NUMERICAL MODELLING, DEPTH AVERAGED, MIXING

.CHANNEL TYPE THRY, EXP, COMP, SMTH

.FL .FW .FD

.CL .CW .CD

.FCS .Q .INST

.AUTHOR BOZZANI A, MOLINARO P, ANDREOLA M, STROBINO G .PUB'N 23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989

.TITLE MATHEMATICAL MODELLING OF TRANSPORT AND DISPERSION OF POLLUTANTS IN RIVERS.AN EXPERIENCE DEVELOPED AT ENEL.

.DATA DISTRIBUTION COEFF., TIME, CONCENTRATION, DEPOSITION COEFF., EROSION COEFF., SHEAR STRESS

.KEY WORDS NUMERICAL MODEL, POLLUTANTS, DISPERSION

.CHANNEL TYPE THRY, PROTO, SIMP, RGH

.FL .FW .FD

.CL .CW .CD

.FCS .Q .INST

.AUTHOR CHAPMAN R S, KUO C Y .PUB'N INT. J. FOR NUMERICAL METHODS IN FLUIDS, VOL 5, 1985

.TITLE APPLICATION OF THE 2 EQUATION k-e TURB. MODEL TO A 2D STEADY,FREE SURFACE FLOW PROBLEM WITH SEPARATION

.DATA DEPTH AVERAGED VELOCITY FIELD, VELOCITY, ASPECT RATIO, REATTACHMENT LENGTH

.KEY WORDS TURBULENCE MODEL, FINITE DIFFERENCE, FREE SURFACE FLOW, CHANNEL EXPANSION, QUICK.

.CHANNEL TYPE THRY, EXP, SIMP, SMTH, EXPANSION

.FL .FW .FD

.CL .CW .CD

.FCS 5(-4) .Q .INST

AUTHOR CHAPMAN R S, KUO C Y

PUB'N INT. J. FOR NUMERICAL METHODS IN FLUIDS, VOL 3, 1983

TITLE APPLICATION OF A HIGH ACCURACY FINITE DIFFERENCE TECHNIQUE TO STEADY,FREE SURFACE FLOW PROBLEMS

DATA WATER SURFACE PROFILES, DEPTH AVERAGED VELOCITY FIELD

KEY WORDS QUICK, FINITE DIFFERENCE, FREE SURFACE FLOW

CHANNEL TYPE THRY, SIMP, SMTH, EXPANSION

FL	FW	FD
CL	CW	CD
FCS	Q	INST

AUTHOR CHATWIN P C, SULLIVAN P J

PUB'N J FLUID MECHANICS, VOL 120, 1982

TITLE THE EFFECT OF ASPECT RATIO ON LONGITUDINAL DIFFUSIVITY IN RECTANGULAR CHANNELS

DATA LONGITUDINAL DIFFUSIVITY, ASPECT RATIO

KEY WORDS DIFFUSIVITY, LAMINAR FLOW, TURBULENT FLOW, ASPECT RATIO

CHANNEL TYPE EXP, THRY, SIMP, RGH

FL	FW 19.1, 38.1 CM	FD
CL	CW 19.1, 38.1 CM	CD
FCS	Q	INST

AUTHOR CHAUDRY M H, BHALLAMUDI S M

PUB'N J HYDRAULIC RESEARCH, VOL 26, 1988, NO 4

TITLE COMPUTATION OF CRITICAL DEPTH IN SYMMETRICAL COMPOUND CHANNELS

DATA SPECIFIC ENERGY, DEPTH, FROUDE, WATER SURFACE PROFILES

KEY WORDS COMPOUND CHANNEL, CRITICAL DEPTH

CHANNEL TYPE THRY, EXP, COMP, SMOOTH

FL	FW	FD
CL	CW	CD
FCS	Q	INST

AUTHOR CHIEN R, CHUNG J N, TROUTT T R

PUB'N INT. J. FOR NUMERICAL METHODS IN FLUIDS, VOL 9, 1989

TITLE MOMENTUM TRANSPORT IN A TURBULENT MIXING LAYER

DATA FLOW FIELD, VELOCITY, TURBULENT INTENSITY, REYNOLDS STRESS, MOMENTUM FLUX & THICKNESS

KEY WORDS MOMENTUM TRANSPORT, TURBULENT MIXING LAYERS, DISCRETE VORTEX METHOD

CHANNEL TYPE THRY, EXP, SIMP, SMTH

FL	FW	FD
CL	CW	CD
FCS	Q	INST

AUTHOR CHIU C L, KARAFFA W

PUB'N 23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989

TITLE A NEW VELOCITY DISTRIBUTION EQUATION FOR ESTIMATION OF DIFFUSION COEFFICIENT

DATA NORMALISED DEPTH, VELOCITY DISTRIBUTION EQUATION, S, VEL. GRADIENTS, DIFFUSION COEFF., SEDIMENT CONC.

KEY WORDS DIFFUSION, POLLUTANT, OPEN CHANNELS

CHANNEL TYPE THRY, EXP, SIMP, RGH

FL	FW	FD
CL	CW	CD
FCS	Q	INST

AUTHOR CHU V H, BABARUTSI S

PUB'N 23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989

TITLE MODELLING THE TURBULENT MIXING LAYERS IN A SHALLOW OPEN CHANNEL

DATA TURBULENT VELOCITY FLUCTUATION, MAX. SLOPE WIDTH, MIXING LAYER

KEY WORDS OPEN CHANNEL, MIXING LAYER, TURBULENCE

CHANNEL TYPE THRY, EXP, SIMP, SMTH

FL	FW 0.61 M	FD 0.13 M
CL	CW 0.61 M	CD 0.13 M
FCS	Q	INST HOT FILM ANEMOMETER

AUTHOR DAWKINS R A, DAVIES D R

PUB'N J FLUID MECHANICS, VOL 108, 1981

TITLE THE EFFECTS OF SURFACE TOPOGRAPHY ON MOMENTUM AND MASS TRANSFER IN A TURBULENT BOUNDARY LAYER

DATA VELOCITY PROFILES, PRESSURE DISTRIBUTION, FRICTION VELOCITY, CONCENTRATION

KEY WORDS MOMENTUM, MASS TRANSFER, BOUNDARY LAYER, TURBULENCE, DIFFUSION, EVAPORATION RATE

CHANNEL TYPE EXP, THRY, SIMP, SMTH, DUCT

FL 10.5 M	FW 0.9 M	FD 0.5 M
CL 1.5 M	CW 0.9 M	CD 0.5 M
FCS	Q AIR	INST PITOT TUBE

AUTHOR DEMUREN A O, RODI W

PUB'N J FLUID MECHANICS, VOL 172, 1986

TITLE CALCULATION OF FLOW AND POLLUTANT DISPERSION IN MEANDERING CHANNELS

DATA VELOCITY VECTOR, VELOCITY PROFILES, CONCENTRATION PROFILES, BED SHEAR STRESS

KEY WORDS COMPOUND CHANNEL, DISPERSION, FLOW, MEANDERS, TURBULENCE MODEL

CHANNEL TYPE EXP, THRY, SIMP, SMTH, RGH, MEANDER

FL 20, 30M	FW 0.254, 2.34 M	FD
CL 20, 30 M	CW 0.254, 2.34 M	CD
FCS	Q	INST TRACER

AUTHOR DJORDJEVIC S, PETROVIC J, MAKSIMOVIC C ET AL

PUB'N HYDROCOMP 89, DUBROVNIK, YUGOSLAVIA, JUNE, 1989

TITLE EXPERIMENTAL TRACER INVESTIGATIONS IN A COMPOUND LABORATORY CHANNEL

DATA VELOCITY DISTRIBUTION, CONCENTRATIONS

KEY WORDS COMPOUND CHANNEL, DISPERSION COEFFICIENT

CHANNEL TYPE EXP, COMP, SMOOTH

FL 34.2 M	FW 0.7 M	FD
CL 23.7 M	CW 0.35 M	CD
FCS 1.5(-2)	Q 12.9 - 28 L/S	INST COLORIMETER, V-NOTCH

AUTHOR ELLIOTT S C A, SELLIN R H J

PUB'N J HYDRAULIC RESEARCH (ACCEPTED FOR PUBLICATION 1989)

TITLE SERC FLOOD CHANNEL FACILITY : SKEWED FLOW EXPERIMENTS

DATA SKEW ANGLE, DEPTH & VEL RATIO, ROUGHNESS, ISOVELS, BOUNDARY SHEAR STRESS, APPARENT SHEAR FORCE

KEY WORDS SKEWED COMPOUND CHANNEL, SHEAR STRESS, SECONDARY FLOW

CHANNEL TYPE EXP, COMP, SMOOTH, RGH, SKEW

FL 56 M	FW 10 M	FD
CL 50 M	CW 1.50 M	CD 0.15 M
FCS 1.027(-3)	Q 0 - 1.1 CUMECS	INST MINIATURE CURRENT METERS, PRESTON TUBE, DIRECTIONAL VANES

AUTHOR ERVINE D A, JASEM H K

PUB'N 23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989

TITLE FLOOD MECHANISMS IN MEANDERING CHANNELS WITH FLOODPLAIN FLOW

DATA RELATIVE DEPTH, HEAD LOSS COEFF., VELOCITY PROFILE, ISOVELS, DEPTH, % DISCHARGE ERROR

KEY WORDS COMPOUND CHANNELS, MEANDERS, FLOW SUB-DIVISION

CHANNEL TYPE THRY, EXP, COMP, SMTH, RGH, MEANDER

FL 10 M	FW 0.8 M	FD
CL 10 M	CW 0.14 M	CD 0.061 M
FCS 1(-3)	Q 0.06 CUMECS	INST POINT GAUGES, MIN. CURRENT METER, DIRECTIONAL VANE

AUTHOR FODEMSKI T R, VOKE P R, COLLINS M W

PUB'N INT. J. FOR NUMERICAL METHODS IN FLUIDS, VOL 7, 1987

TITLE FLOW SIMULATION IN CHANNELS WITH DISTORTED GEOMETRY USING A SPECTRAL CODE WITH CO-ORDINATE TRANSFORMATION

DATA TURBULENT KINETIC ENERGY, TIME, VELOCITY FIELD

KEY WORDS LARGE EDDY SIMULATION, SPECTRAL METHODS, CO-ORDINATE TRANSFORMATION

CHANNEL TYPE THRY, EXP, SIMP, SMTH, RGH

FL	FW	FD
CL	CW	CD
FCS	Q	INST

AUTHOR FUJISAKI K, TANIGAWA H, AWAYA Y		PUB'N J. OF HYDROSCIENCE AND HYDRAULIC ENGINEERING, VOL 6, DECEMBER, 1988
TITLE ON THE DISPERSION PHENOMENA OF SUSPENDED SOLID IN TURBULENT OPEN CHANNEL FLOW		
DATA CONC DISTRIBUTION, VELOCITY, DISPERSION COEFF, CONC DECAY, TURBIDITY, REYNOLDS NO.		KEY WORDS DISPERSION, TURBULENCE
CHANNEL TYPE THRY, EXP, SIMP, RGH		
FL 8 M	FW 0.4 M	FD
CL 8 M	CW 0.4 M	CD
FCS	Q	INST TURBIDITY METER, CONDUCTIVITY METER

AUTHOR GEORGIEV B V		PUB'N 23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989
TITLE BED LOAD TRANSPORT IN FLOODPLAIN DURING HIGH WATERS		
DATA GRAIN SIZE DISTRIBUTION, FLOOD HYDROGRAPH, SHEAR STRESS, VELOCITY PROFILE, BED LOAD DISTRIBUTION		KEY WORDS COMPOUND CHANNEL, SEDIMENT TRANSPORT
CHANNEL TYPE PROTO, COMP, RGH		
FL	FW	FD
CL	CW 33.5 M	CD 1.6 M
FCS 1.25(-2)	Q 122 - 450 CUMECS	INST LEVEL RECORDER, CURRENT METER, SEDIMENT TRAP

AUTHOR GIBSON M M, RODI W		PUB'N J. HYDRAULIC RESEARCH, VOL 27, 1989, NO. 2
TITLE SIMULATION OF FREE SURFACE EFFECTS ON TURBULENCE WITH A REYNOLDS STRESS MODEL		
DATA TURBULENT ENERGY DISTRIBUTION, TURBULENT LENGTH SCALE, SURFACE PROXIMITY FUNCTION, DEPTH RATIO		KEY WORDS TURBULENCE, REYNOLDS STRESS
CHANNEL TYPE THRY, EXP, SIMP, SMOOTH, RGH		
FL	FW	FD
CL	CW	CD
FCS	Q	INST

AUTHOR HACKMAN L P, RAITHBY G D, STRONG A B

PUB'N INT. J. FOR NUMERICAL METHODS IN FLUIDS, VOL 4, 1984

TITLE NUMERICAL PREDICTIONS OF FLOWS OVER BACKWARD FACING STEPS

DATA REATTACHMENT LENGTH, REYNOLDS NO., VELOCITY PROFILE, TURBULENT KINETIC ENERGY, REYNOLDS STRESS

KEY WORDS FINITE VOLUME METHOD, TURBULENCE MODEL, NUMERICAL DIFFUSION

CHANNEL TYPE THRY, EXP, SIMP, SMTH, STEP

FL	FW	FD
CL	CW	CD
FCS	Q	INST

AUTHOR HASEGAWA K

PUB'N PASCE, J HYD D, VOL 115, 6, JUNE, 1989

TITLE UNIVERSAL BANK EROSION COEFFICIENT FOR MEANDERING RIVERS

DATA MIGRATION LENGTH, BANK EROSION RATE, VEL RATIO, SCOURING FACTOR, BANK EROSION COEFF, PENETRATION

KEY WORDS MEANDERS, BANK EROSION

CHANNEL TYPE THRY, PROTO, SIMP, RGH, MEANDERS

FL	FW	FD
CL 1000, 4000 M	CW 80, 140 M	CD 1.3, 6.5 M
FCS	Q	INST

AUTHOR HESLOP S E, ALLEN C M

PUB'N 23RD CONGRESS, 1AHR, OTTAWA, AUGUST, 1989

TITLE TURBULENCE AND DISPERSION IN LARGER U.K. RIVERS

DATA VELOCITY AVERAGED CONCENTRATION, TURBULENT VELOCITIES

KEY WORDS OPEN CHANNELS, TURBULENCE, DISPERSION

CHANNEL TYPE PROTO, SIMP, RGH

FL	FW	FD
CL	CW 45, 60 M	CD 1.2, 2 M
FCS	Q 20 - 43 CUMECS	INST ELECTROMAGNETIC CURRENT METER, TRACER

.AUTHOR HUANG W W L .PUB'N 23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989

.TITLE THE VEL. PROF. FORMULA ALONG SECT. OF OPEN CHAN. FLOW DETERMINED BY THE LAW OF MAX. RATE OF ENERGY DISSIP..

.DATA TURBULENT CORE, LAMINAR FILM, VELOCITY PROFILE FORMULA

.KEY WORDS OPEN CHANNEL, VELOCITY PROFILE, ENERGY DISSIPATION

.CHANNEL TYPE THRY, EXP, SIMP, RGH

.FL .FW 2.439 M .FD

.CL .CW 2.439 M .CD

.FCS 3.4(-4) .Q 0.0969 CUMECS .INST PITOT TUBE

.AUTHOR HYDRAULICS RESEARCH LIMITED .PUB'N INT. CONF. ON RIVER REGIME, WALLINGFORD, MAY, 1988

.TITLE INTERNATIONAL CONFERENCE ON RIVER REGIME

.DATA RIVER MORPHOLOGY, ANALYTICAL APPROACH, EMPIRICAL APPROACH, FIELDWORK, LABORATORY STUDIES

.KEY WORDS RIVER REGIME, MEANDERS, BRAIDS, STRAIGHT CHANNELS, SEDIMENT LOAD, FRICTION FACTOR

.CHANNEL TYPE PROTO, EXP, THRY, SMTH, RGH

.FL .FW .FD

.CL .CW .CD

.FCS .Q .INST

.AUTHOR IMAMOTO H, ISHIGAKI T .PUB'N HYDROCOMP 89, DUBROVNIK, YUGOSLAVIA, JUNE, 1989

.TITLE SECONDARY FLOW IN COMPOUND OPEN CHANNEL

.DATA MEAN VELOCITY, TURBULENCE INTENSITY, SHEAR STRESS, SECONDARY FLOW CELLS

.KEY WORDS COMPOUND CHANNEL, SECONDARY FLOW, SHEAR STRESS

.CHANNEL TYPE EXP, COMP, SMOOTH

.FL .FW .FD

.CL .CW 0.2, 1.00 M .CD 0.01, 0.06 M

.FCS 5.88 - 20(-4) .Q 0.32 - 24.5 L/S .INST MIN CURRENT METER, HOT FILM ANEM, HYDROGEN BUBBLES, TRACER, CAMERA

AUTHOR IMAMOTO H, ISHIGAKI T, NISHIDA M		PUB'N 23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989
TITLE TURBULENCE,SECONDARY FLOW AND BOUNDARY SHEAR STRESS IN A TRAPEZOIDAL OPEN CHANNEL		
DATA VELOCITY, TURBULENCE INTENSITY, SECONDARY FLOW CELLS, BOUNDARY SHEAR STRESS		KEY WORDS OPEN CHANNEL, SECONDARY FLOW, TURBULENCE, SHEAR STRESS
CHANNEL TYPE EXP, SIMP, SMTH		
FL 13 M	FW 0.39 M	FD
CL 13 M	CW 0.2, 0.39 M	CD
FCS 1.25(-3)	Q 0.0009 - 0.00568 LITRES/SEC	INST PRESTON TUBE, CAMERA, VIDEO

AUTHOR JOHANSSON A V, HENRIK ALFREDSSON P		PUB'N J FLUID MECHANICS, VOL 122, 1982
TITLE ON THE STRUCTURE OF TURBULENT CHANNEL FLOW		
DATA VELOCITY, TURBULENCE INTENSITY, FREQUENCY SPECTRA		KEY WORDS FLOW STRUCTURE, TURBULENCE, REYNOLDS NO.
CHANNEL TYPE EXP, THRY, SIMP, SMTH, DUCT		
FL	FW 0.4 M	FD 0.08 M
CL	CW 0.4 M	CD 0.08 M
FCS	Q	INST LASER DOPPLER ANEMOMETER, HOT FILM PROBE

AUTHOR JUNGSONG D, SHUDONG W		PUB'N J OF SEDIMENT RESEARCH, 1, 1989, BEIJING
TITLE EXPERIMENTAL RESEARCH ON FLOW STRUCTURE AND MOVEMENT OF SUSPENDED SEDIMENT OF OVERBANK FLOW		
DATA ISOVELS, VELOCITY, STAGE, SEDIMENT CONCENTRATION, SEDIMENT FLUX		KEY WORDS COMPOUND CHANNEL, SEDIMENT CONCENTRATION, TURBULENCE
CHANNEL TYPE EXP, SIMP, COMP, RGH		
FL 18 M	FW 2 M	FD
CL 12 M	CW 0.6 M	CD 0.1 M
FCS 1(-3)	Q 77.9 LITRES/SEC	INST

AUTHOR KASTRINAKIS E G, ECKELMANN H

PUB'N J FLUID MECHANICS, VOL 137, 1983

TITLE MEASUREMENT OF STREAMWISE VORTICITY FLUCTUATIONS IN A TURBULENT CHANNEL FLOW

DATA TRANSVERSE VELOCITY COMPONENT, CALIBRATION FACTOR

KEY WORDS VORTICITY, TURBULENCE

CHANNEL TYPE EXP, THRY, SIMP, RGH, DUCT

FL 9.5 M	FW 0.18 M	FD 1.40 M
CL 9.5 M	CW 0.18 M	CD 1.40 M
FCS	Q AIR	INST VORTICITY PROBE

AUTHOR KAUL U K, KWAK D

PUB'N INT. J. FOR NUMERICAL METHODS IN FLUIDS, VOL 6, 1986

TITLE COMPUTATION OF INTERNAL TURBULENT FLOW WITH A LARGE SEPARATED FLOW REGION

DATA TURBULENT KINETIC ENERGY, WALL FLUX & BOUNDARY, VEL. PROF., TURB. SHEAR STRESS, PRESSURE DISTRIBUTION

KEY WORDS TWO EQUATION TURBULENCE MODEL, SEPARATED FLOW

CHANNEL TYPE EXP, THRY, SIMP, SMTH, STEP

FL	FW	FD
CL	CW	CD
FCS	Q	INST

AUTHOR KAWAHARA M, UMETSU T

PUB'N INT. J. FOR NUMERICAL METHODS IN FLUIDS, VOL 6, 1986

TITLE FINITE ELEMENT METHOD FOR MOVING BOUNDARY PROBLEMS IN RIVER FLOW

DATA STAGE, CHAINAGE, VELOCITY, CRITICAL DEPTH, FROUDE NO.

KEY WORDS FINITE ELEMENT EQUATION, MOVING BOUNDARY

CHANNEL TYPE THRY, PROTO, SIMP, SMTH, RGH

FL	FW	FD
CL 75, 2150 M	CW 8, 200 M	CD
FCS	Q	INST

AUTHOR KAWAHARA Y, TAMAI N		PUB'N 23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989
TITLE MECHANISM OF LATERAL MOMENTUM TRANSFER IN COMPOUND CHANNEL FLOWS		
DATA VELOCITY, SECONDARY FLOW, TURBULENT SHEAR STRESS, MOMENTUM TRANSFER, APPARENT SHEAR STRESS		KEY WORDS MOMENTUM TRANSFER, COMPOUND CHANNEL, SHEAR STRESS, NUMERICAL MODEL
CHANNEL TYPE THRY, EXP, COMP, SMTH, RGH		
FL	FW	FD
CL	CW 0.087, 0.16 M	CD 0.04, 0.05 M
FCS	Q	INST

AUTHOR KNIGHT D W, SHIONO K		PUB'N J HYDRAULIC RESEARCH (ACCEPTED FOR PUBLICATION 1989)
TITLE TURBULENCE MEASUREMENTS IN A SHEAR LAYER REGION OF A COMPOUND CHANNEL		
DATA DEPTH, VELOCITY, TURBULENT INTENSITY & KINETIC ENERGY, SHEAR STRESS, EDDY VISCOSITY, FRICTION FACTOR		KEY WORDS COMPOUND CHANNEL, TURBULENCE, REYNOLDS STRESS, FRICTION FACTOR, EDDY VISCOSITY
CHANNEL TYPE EXP, COMP, SMOOTH		
FL 56 M	FW 10 M	FD
CL 50 M	CW 1.5 M	CD 0.15 M
FCS 1.027(-3)	Q 0 - 1.1 CUMECS	INST LASER DOPPLER ANEMOMETER

AUTHOR KNIGHT D W, SHIONO K, PIRT J		PUB'N INT CONF HYD & ENVIRON MOD OF COASTAL, ESTUARINE & RIVER WATERS, BRADFORD, 1989.
TITLE PREDICTION OF DEPTH MEAN VELOCITY AND DISCHARGE IN NATURAL RIVERS WITH OVERBANK FLOW		
DATA STAGE, HYDRAULIC RADIUS, MANNINGS n, DARCY-WEISBACH, VELOCITY, REYNOLDS NO., FRICTION SLOPE		KEY WORDS COMPOUND CHANNEL, DISCHARGE ESTIMATION, FRICTION FACTOR
CHANNEL TYPE THRY, PROTO, COMP, RGH		
FL	FW	FD
CL	CW 17 M	CD 6 M
FCS 2(-4)	Q 106.5 - 330.8 CUMECS	INST

AUTHOR KNIGHT D W		PUB'N UNIVERSITY OF BIRMINGHAM, DEPT OF CIVIL ENGINEERING, SEPT., 1989
TITLE SERC FLOOD CHANNEL FACILITY, STRAIGHT CHANNEL DATA, SERIES 1 -13 (PROVISIONAL)		
DATA STAGE, DISCHARGE, VELOCITY, SHEAR STRESS		KEY WORDS COMPOUND CHANNEL, SHEAR STRESS,
CHANNEL TYPE EXP, COMP, SMTH, RGH		
FL 49.67 M	FW 9.972 M	FD
CL 49.67 M	CW 1.500 M	CD 0.150 M
FCS 1.027(-3)	Q 0 - 1.1 CUMECS	INST LASER DOPPLER ANEMOMETER, MIN CURRENT METERS, PRESTON TUBE

AUTHOR KOMORI S, UEDA H, OGINO F, MIZUSHINA T		PUB'N INT. J. HEAT MASS TRANSFER, VOL 25, NO. 4, 1982
TITLE TURBULENCE STRUCTURE AND TRANSPORT MECHANISM AT THE FREE SURFACE IN AN OPEN CHANNEL FLOW		
DATA TURBULENCE KINETIC ENERGY & INTENSITIES, HEAT FLUX RATIO, VELOCITY FLUCTUATION, SPACE CORRELATION		KEY WORDS TURBULENCE STRUCTURE, MASS TRANSFER, TURBULENCE INTENSITY
CHANNEL TYPE EXP, THRY, SIMP, SMTH		
FL 6.1 M	FW 0.3 M	FD 0.06 M
CL 6.1 M	CW 0.3 M	CD
FCS	Q	INST LASER DOPPLER VELOCIMETER, COLD FILM PROBE

AUTHOR KOMORI S, UEDA H, OGINO F, MIZUSHINA T		PUB'N J FLUID MECHANICS, VOL 130, 1983
TITLE TURBULENCE STRUCTURE IN STABLY STRATIFIED OPEN CHANNEL FLOW		
DATA VELOCITY, TEMPERATURE, TURBULENCE KINETIC ENERGY, VERTICAL HEAT FLUX, SHEAR STRESS		KEY WORDS TURBULENCE STRUCTURE, STRATIFIED FLOW
CHANNEL TYPE EXP, THRY, SIMP, SMTH		
FL 6.1 M	FW 0.3 M	FD 0.06 M
CL 4.5 M	CW 0.3 M	CD 0.06 M
FCS	Q	INST LASER DOPPLER VELOCIMETER, COLD FILM PROBE

.AUTHOR KOTSOVINOS N E
.PUB'N APPL. MATH. MODELLING, 1988, VOL 12, FEBRUARY.

.TITLE SECONDARY CURRENTS IN STRAIGHT WIDE CHANNELS

.DATA

.KEY WORDS SECONDARY CURRENTS, MARGINAL STABILITY, TURBULENCE

.CHANNEL TYPE THRY, PROTO, EXP, SIMP, SMTH, RGH

.FL	.FW	.FD
.CL	.CW	.CD
.FCS	.Q	.INST

.AUTHOR KRUGER F, BOLLRICH G
.PUB'N 23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989

.TITLE BOUNDARY SHEAR DISTRIBUTION IN RECT. & TRAPEZ. CHANNELS WITH UNIFORM & NON UNIFORM BED & WALL ROUGHNESS.

.DATA BED STRESS, WALL STRESS, DEPTH/WIDTH RATIO

.KEY WORDS BOUNDARY SHEAR, ROUGHNESS RATIOS

.CHANNEL TYPE EXP, THRY, SIMP, RGH

.FL 28 M	.FW 0.25 M	.FD
.CL 28 M	.CW 0.25 M	.CD
.FCS 1(-3)	.Q	.INST SHEAR PLATE, PRESTON TUBE

.AUTHOR LARSSON R
.PUB'N 23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989

.TITLE LATERAL MIXING IN OPEN CHANNELS - THE IMPORTANT PROCESSES

.DATA LATERAL WIND STRESS, CORIOLIS FORCE, REYNOLDS STRESS, DEPTH AVERAGED CONC., SECONDARY CURRENTS

.KEY WORDS OPEN CHANNELS, LATERAL MIXING

.CHANNEL TYPE EXP, THRY, PROTO, SIMP, SMTH, RGH

.FL	.FW	.FD
.CL	.CW	.CD
.FCS	.Q	.INST

.AUTHOR LEAN G H, WEARE T J
.PUB'N PASCE, J HYD
.D, VOL 105, HY1,
.JANUARY, 1979

.TITLE MODELLING TWO DIMENSIONAL CIRCULATING FLOW

.DATA VELOCITY, LATERAL SHEAR STRESS

.KEY WORDS NUMERICAL
.MODEL, CIRCULATING
.FLOW, SHEAR STRESS,
.EDDY VISCOSITY

.CHANNEL TYPE EXP, THRY, SIMP, RGH

.FL 32 M .FW 10.4 M .FD

.CL 32 M .CW 10.4 M .CD

.FCS .Q .INST

.AUTHOR LI S
.PUB'N 23RD CONGRESS,
.IAHR, OTTAWA,
.AUGUST, 1989

.TITLE THEORETICAL LONGITUDINAL DISPERSION COEFFICIENT
.FOR NATURAL RIVERS - A STOCHASTIC APPROACH

.DATA

.KEY WORDS OPEN
.CHANNELS, DISPERSION
.COEFFICIENT

.CHANNEL TYPE THRY, EXP, PROTO, SIMP, SMTH, RGH

.FL .FW .FD

.CL .CW .CD

.FCS .Q .INST

.AUTHOR LIREN Y, SHU-NONG Z
.PUB'N 23RD CONGRESS,
.IAHR, OTTAWA,
.AUGUST, 1989

.TITLE A NEW DEPTH AVERAGED TWO EQUATION (k-w) TURBULENT
.CLOSURE MODEL AND ITS APPLICATION

.DATA EDDY HEIGHT, EDDY SHAPE, JET WIDTH, VELOCITY,
.TEMPERATURE, EDDY VISCOSITY, MASS SOURCE, ISOTHERMS

.KEY WORDS NUMERICAL
.MODEL, TURBULENCE,
.DIFFUSION

.CHANNEL TYPE THRY, PROTO, SIMP, SMTH

.FL .FW .FD

.CL .CW .CD

.FCS .Q 1.75 - 1550
.CUMECS
.INST

.AUTHOR MANSOUR N N, KIM J, MOIN P

.TITLE REYNOLDS STRESS AND DISSIPATION RATE BUDGETS IN A TURBULENT CHANNEL FLOW

.PUB'N J FLUID MECHANICS, VOL 194, 1988

.DATA TURBULENT TRANSPORT, VISCOUS DIFFUSION, DISSIPATION RATE, VELOCITY PRESSURE GRADIENT, PRESSURE STRAIN

.KEY WORDS TURBULENCE, REYNOLDS STRESS, DISSIPATION, DIFFUSION

.CHANNEL TYPE EXP, THRY, SIMP, SMTH

.FL .FW .FD

.CL .CW .CD

.FCS .Q .INST

.AUTHOR MARKATOS N C

.TITLE THE MATHEMATICAL MODELLING OF TURBULENT FLOWS

.PUB'N APPL. MATH. MODELLING, 1986, VOL 10, JUNE

.DATA BOUNDARY LAYER, ENERGY SPECTRA, TURBULENCE ENERGY, NUSSELT NO., SHEAR STRESS, TURBULENT WAKE

.KEY WORDS TURBULENCE, STRESS EQUATION, DISSIPATION, TIME SCALES, EDDIES, VISCOSITY

.CHANNEL TYPE

.FL .FW .FD

.CL .CW .CD

.FCS .Q .INST

.AUTHOR McKEOGH E J, KIELY G K

.TITLE EXPERIMENTAL STUDY OF THE MECHANISMS OF FLOOD FLOW IN MEANDERING CHANNELS

.PUB'N 23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989

.DATA VELOCITY VECTORS, VELOCITY, DEPTH

.KEY WORDS COMPOUND CHANNELS, MEANDERS, FLOW MECHANISM, ENERGY LOSS

.CHANNEL TYPE EXP, THRY, COMP, SMTH, MEANDER

.FL 14.4 M .FW 1.2 M .FD 0.5 M

.CL 14.4 M .CW 0.2 M .CD 0.05 M

.FCS .Q 3.1 - 11.1 LITRES/SEC .INST LASER DOPPLER ANEMOMETER

AUTHOR McKEOGH E J, KIELY G K, JAVAN M

TITLE VEL. & TURB. MEASUREMENTS IN A STRAIGHT CHANNEL WITH INTERACTING FLOODPLAINS USING LASER DOPPLER ANEM.

PUB'N INT CONF HYD & ENVIRON MOD OF COASTAL,ESTUARINE & RIVER WATERS, BRADFORD, 1989.

DATA ISOVELS, TURBULENCE INTENSITY, VELOCITY DISTRIBUTION

KEY WORDS COMPOUND CHANNEL, TURBULENCE INTENSITY

CHANNEL TYPE EXP, THRY, COMP, SMTH

FL 14.4 M	FW 1.2 M	FD 0.5 M
CL 14.4 M	CW 0.2 M	CD 0.05 M
FCS 1(-3)	Q 0.01 - 0.0306 CUMECS	INST LASER DOPPLER ANEMOMETER

AUTHOR MOHN R, HANSCHEID P, ROUVE G

TITLE DETERMINATION OF SURFACE ROUGHNESS FOR SIMULATIONS OF NATURAL RIVER RUNOFF

PUB'N 22ND IAHR CONGRESS, LAUSANNE, 1987

DATA DIGITIZED IMAGING, INTENSITY TRANSFORMATION FUNCTION, DIGITAL DATABASE

KEY WORDS CHANNEL ROUGHNESS, IMAGE PROCESSING

CHANNEL TYPE PROTO, COMP, RGH

FL	FW	FD
CL	CW	CD
FCS	Q	INST

AUTHOR MORGAN K, HUGHES T G, TAYLOR C

TITLE INVESTIGATION OF A MIXING LENGTH AND A TWO EQUATION TURBULENCE MODEL UTILIZING A FINITE ELEMENT METHOD

PUB'N APPL. MATH. MODELLING, 1977, VOL 1, DECEMBER

DATA VELOCITY PROFILE, TURBULENT KINETIC ENERGY, TURBULENT VISCOSITY

KEY WORDS MIXING LENGTH, PIPE FLOW, CHANNEL FLOW, TURBULENCE, VISCOSITY

CHANNEL TYPE THRY, EXP, SIMP, SMTH

FL	FW	FD
CL	CW	CD
FCS	Q	INST

AUTHOR MUELLER A

PUB'N 15TH CONGRESS, IAHR, ISTANBUL, 1973, VOL 1

TITLE TURBULENCE MEASUREMENTS OVER A MOVABLE BED WITH SEDIMENT TRANSPORT BY LASER ANEMOMETRY

DATA DEPTH, MEAN VELOCITY, TURBULENCE INTENSITY, TURBULENT FLUCTUATION AUTOCORRELATION

KEY WORDS TURBULENCE, SEDIMENT TRANSPORT

CHANNEL TYPE EXP, SIMP, RGH

FL 7 M — FW 0.15 M — FD 0.15 M

CL 7 M — CW 0.15 M — CD

FCS 2.27(-2) — Q 2600/2650 CUBIC CENTIMETRES / SECOND. — INST LASER DOPPLER ANEMOMETER

AUTHOR MYERS W R C, BRENNAN E K

PUB'N J HYDRAULIC RESEARCH (ACCEPTED FOR PUBLICATION 1989)

TITLE FLOW RESISTANCE IN COMPOUND CHANNELS

DATA FRICTION FACTOR, REYNOLDS NO, MANNINGS, RELATIVE DEPTH, STAGE, VELOCITY RATIO, DISCHARGE RATIO

KEY WORDS COMPOUND CHANNELS, FLOW RESISTANCE, MOMENTUM TRANSFER

CHANNEL TYPE EXP, COMP, SMOOTH

FL 56 M — FW 10 M — FD

CL 50 M — CW 1.5 M — CD 0.15 M

FCS 1.027(-3) — Q 0 - 1.1 CUMECS — INST MINIATURE CURRENT METERS, PRESTON TUBE, POINT GAUGES

AUTHOR NEZU I, NAKAGAWA H, RODI W

PUB'N 23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989

TITLE SIGNIFICANT DIFFERENCE BETWEEN SECONDARY CURRENTS IN CLOSED CHANNELS AND NARROW OPEN CHANNELS

DATA VELOCITY, DEPTH, VORTICITY, TURBULENCE INTENSITY, STREAMLINES, SHEAR STRESS, SECONDARY CURRENT VECTOR

KEY WORDS DUCT, NARROW OPEN CHANNEL, TURBULENCE, SECONDARY CURRENTS

CHANNEL TYPE EXP, SIMP, SMTH, RGH

FL — FW — FD

CL — CW — CD

FCS — Q — INST LASER DOPPLER ANEMOMETER, HOT WIRE ANEMOMETER

.AUTHOR NOKES R I, WOOD I R
.TITLE VERTICAL AND LATERAL TURBULENT DISPERSION:SOME
.EXPERIMENTAL RESULTS

.PUB'N J FLUID MECHANICS, VOL 187, 1988

.DATA LATERAL DIFFUSIVITY, DIFFUSION COEFFICIENT,
.FRICTION FACTOR, ISOVELS, CONCENTRATION PROFILES
.CHANNEL TYPE EXP, THRY, SIMP, SMTH

.KEY WORDS DIFFUSIVITY, FRICTION FACTOR, TURBULENCE

.FL 12 M	.FW 560 MM	.FD 430 MM
.CL 12 M	.CW 560 MM	.CD
.FCS 4.7(-4)	.Q	.INST

.AUTHOR ODGAARD A J
.TITLE RIVER - MEANDER MODEL. 1 : DEVELOPMENT

.PUB'N PASCE, J HYD D, VOL 115, HY11, NOVEMBER, 1989

.DATA BED SLOPES, WAVELENGTH, PHASE SHIFT, WIDTH -
.DEPTH RATIO
.CHANNEL TYPE THRY, PROTO, EXP, RGH, MEANDERS

.KEY WORDS MEANDERS, COMPUTATIONAL MODEL, MEANDER FLOW, PLANFORM DEVELOPMENT

.FL	.FW	.FD
.CL	.CW	.CD
.FCS	.Q	.INST

.AUTHOR ODGAARD A J
.TITLE RIVER - MEANDER MODEL. 2 : APPLICATIONS

.PUB'N PASCE, J HYD D, VOL 115, HY11, NOVEMBER, 1989

.DATA MEANDER WAVELENGTHS, MIGRATION RATES, EROSION
.VELOCITIES, DEPTH, VELOCITY
.CHANNEL TYPE THRY, PROTO, EXP, RGH, MEANDERS

.KEY WORDS MEANDERS, PLANFORM DEVELOPMENT, MEANDER FLOW

.FL	.FW	.FD
.CL	.CW	.CD
.FCS	.Q	.INST

.AUTHOR PRINOS P
.PUB'N HYDROCOMP 89, DUBROVNIK, YUGOSLAVIA, JUNE, 1989

.TITLE EXPERIMENTS AND NUMERICAL MODELLING IN COMPOUND OPEN CHANNEL AND DUCT FLOWS

.DATA AVERAGE VELOCITY, BOUNDARY SHEAR STRESS, ISOVELS

.KEY WORDS COMPOUND CHANNELS, DUCTS, DEPTH AVERAGED MODEL, THREE DIMENSIONAL MODEL

.CHANNEL TYPE EXP, THRY, COMP, SMTH

.FL 12.2 M	.FW 24 IN	.FD 6 IN
.CL	.CW 6 IN	.CD 4 IN
.FCS	.Q	.INST HOT FILM & HOT WIRE ANEMOMETER, PRESTON TUBE

.AUTHOR PRINOS P, TOWNSEND R D
.PUB'N PROC. NUMERICAL METHODS IN LAMINAR AND TURBULENT FLOW, SWANSEA, 1985

.TITLE NUMERICAL MODELLING OF TURBULENT FLOW IN COMPOUND OPEN CHANNELS

.DATA VELOCITY, SHEAR STRESS

.KEY WORDS COMPOUND CHANNEL, NUMERICAL METHOD

.CHANNEL TYPE EXP, THRY, COMP, SMTH, RGH

.FL 12.2 M	.FW	.FD
.CL 12.2 M	.CW 0.102, 0.290 M	.CD 0.03, 0.102 M
.FCS 3/10(-4)	.Q	.INST PITOT TUBE, PRESSURE TRANSDUCER, PRESTON TUBE

.AUTHOR PRINOS P, TOWNSEND R D
.PUB'N ADV WATER RESOURCES, VOL 7, DECEMBER, 1984

.TITLE COMPARISON OF METHODS FOR PREDICTING DISCHARGE IN COMPOUND OPEN CHANNELS

.DATA APPARENT SHEAR STRESS, DISCHARGE DISCREPANCY, RELATIVE DEPTH

.KEY WORDS DISCHARGE, COMPOUND CHANNELS,

.CHANNEL TYPE EXP, THRY, COMP, SMTH, RGH

.FL 12.2 M	.FW 1.372 M	.FD
.CL 12.2 M	.CW 0.203, 0.508 M	.CD 0.102 M
.FCS 3(-4)	.Q 4.8 - 26 LITRES/SEC	.INST PRESTON TUBE

AUTHOR RAJARATNAM N, AHMADI R
PUB'N HYDROCOMP 89, DUBROVNIK, YUGOSLAVIA, JUNE, 1989

TITLE THREE NOTES ON HYDRAULICS OF CHANNELS WITH FLOOD-PLAINS

DATA VEL PROF., BED & WALL SHEAR PROF., TANGENTIAL & RADIAL VEL, WIDTH/DEPTH RATIOS, DEPTH/ROUGHNESS RATIO

KEY WORDS COMPOUND CHANNEL, VELOCITY DISTRIBUTION, SHEAR PROFILES

CHANNEL TYPE EXP, SMOOTH, COMP, MEANDERS

FL 18 M	FW 1.2 M	FD 0.9 M
CL 18 M	CW 0.254 M	CD 0.0381 M
FCS	Q	INST PITOT TUBE, YAW TUBE, TRANSDUCER

AUTHOR RASPOPIN G A, KOVALYOV E A
PUB'N 23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989

TITLE RIVER STREAM DYNAMICS MATHEMATICAL MODELLING IN RIVER BED AND FLOOD PLAIN

DATA

KEY WORDS COMPOUND CHANNEL, NUMERICAL MODEL

CHANNEL TYPE THRY, COMP, RGH

FL	FW	FD
CL	CW	CD
FCS	Q	INST

AUTHOR SALIKOV V G
PUB'N HYDROTECH. CONSTR., VOL 19, NO 6, 1985

TITLE ENERGY LOSSES OF A CHANNEL FLOW UNDER CONDITIONS OF OVERFLOW ONTO A FLOODPLAIN

DATA CHANNEL WIDTH, MEANDER BELT WIDTH, CHANNEL ROUGHNESS, FLOODPLAIN ROUGHNESS, FRICTION SLOPE

KEY WORDS COMPOUND CHANNEL, MEANDER, ENERGY LOSS

CHANNEL TYPE EXP, THRY, COMP, RGH, MEANDER

FL	FW	FD
CL	CW	CD
FCS	Q	INST

AUTHOR SAMUELS P G	PUB'N CONF. OF RIVER ENGINEERS, LOUGHBOROUGH, JULY, 1989
TITLE THE HYDRAULICS OF TWO STAGE CHANNELS - REVIEW OF CURRENT KNOWLEDGE	
DATA CONVEYANCE, MEANDERS, VELOCITY DISTRIBUTION, BED SHEAR STRESS, FROUDE NUMBER, STAGE - DISCHARGE	KEY WORDS COMPOUND CHANNELS, MEANDERS, SKEW, CONVEYANCE, BED SHEAR
CHANNEL TYPE EXP, THRY, PROTO, COMP, SMOOTH, RGH	

FL	FW	FD
CL	CW	CD
FCS	Q	INST

AUTHOR SELLIN R H J, GILES A	PUB'N 23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989
TITLE FLOW MECHANISMS IN SPILLING MEANDER CHANNELS	
DATA FLOW DEPTH, ROUGHNESS HEIGHT, DISCHARGE, SURFACE VELOCITY	KEY WORDS COMPOUND CHANNEL, MEANDERS, FLOW MECHANISM
CHANNEL TYPE PROTO, EXP, COMP, RGH, MEANDERS	

FL	FW	FD
CL 6, 300 M	CW	CD
FCS	Q 0.00125 - 40 CUMECS	INST STROBE, CAMERA, POINT GAUGES, DIRECTIONAL VANE, MIN CURRENT METERS

AUTHOR SMITH C D	PUB'N 23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989
TITLE SOME ASPECTS OF FLOOD PLAIN FLOW IN A VALLEY WITH A MEANDERING CHANNEL	
DATA STAGE, DISCHARGE	KEY WORDS MEANDERS, COMPOUND CHANNEL, FLOODPLAIN FLOW
CHANNEL TYPE EXP, PROTO, COMP, SMTH, RGH, MEANDER	

FL 22 M	FW 1.2 M	FD
CL -	CW 0.122 M	CD 0.076 M
FCS 8.5/10(-4)	Q 0.0045 - 0.038 CUMECS	INST POINT GAUGES

.AUTHOR SPREAFICO M, LEIBUNDGUT Ch .PUB'N 23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989

.TITLE TRAVEL TIME AND TRANSPORT FORECASTING OF DISSOLVED MATERIAL WITHIN THE RHINE

.DATA VELOCITY, TRAVEL TIME, FLOOD WAVE, DISCHARGE, TRACER CONC., DISPERSION COEFF., DEPTH

.KEY WORDS OPEN CHANNEL, TRAVEL TIME, DISPERSION, POLLUTANT

.CHANNEL TYPE PROTO, THRY, SIMP, RGH

.FL	.FW	.FD
.CL	.CW 180 M	.CD 11 M
.FCS	.Q 400 - 2400 CUMECS	.INST FLUOROMETER

.AUTHOR STEIN C J, ROUVE G .PUB'N HYDROSOFT, 1989, VOL 2, NO. 1

.TITLE 2D DEPTH AVERAGED NUMERICAL PREDICTIONS OF THE FLOW IN A MEANDERING CHANNEL WITH COMPOUND CROSS SECTION.

.DATA GRID CONFIGURATION, VELOCITY VECTORS, DISCHARGE DISTRIBUTION, VELOCITY PROFILE, SURFACE PROFILE

.KEY WORDS MEANDERS, NUMERICAL MODEL, COMPOUND CHANNEL

.CHANNEL TYPE THRY, EXP, COMP, SMTH, MEANDERS

.FL 15 M	.FW 3 M	.FD
.CL 13.7 M	.CW 0.4 M	.CD 0.1 M
.FCS 5(-3)	.Q 54.61 LITRES/SEC	.INST LASER DOPPLER ANEMOMETER, TRACER, POINT GAUGES

.AUTHOR TALMON A M, KUNEN J M G, OOMS G .PUB'N J FLUID MECHANICS, VOL 163, 1986

.TITLE SIMULTANEOUS FLOW VISUALIZATION AND REYNOLDS STRESS MEASUREMENT IN A TURBULENT BOUNDARY LAYER

.DATA ENERGY SPECTRA, VELOCITY DISTRIBUTION, TURBULENCE, FLUCTUATION MOMENTS, REYNOLDS STRESS

.KEY WORDS REYNOLDS STRESS, TURBULENCE, BOUNDARY LAYER, FLOW STRUCTURE

.CHANNEL TYPE EXP, SIMP, SMOOTH

.FL 280 CM	.FW 150 CM	.FD 12 CM
.CL 210 CM	.CW 50 CM	.CD
.FCS	.Q	.INST LASER DOPPLER ANEMOMETER, HYDROGEN BUBBLES, CAMERA

.AUTHOR TAMAI N, ASAEDA T, IKEDA H
.PUB'N WATER RESOURCES RESEARCH, VOL 22, NO 7, JULY, 1986

.TITLE STUDY ON GENERATION OF PERIODICAL LARGE SURFACE EDDIES IN A COMPOSITE CHANNEL FLOW

.DATA LATERAL VELOCITY PROFILE, FLOW PATTERN, REYNOLDS NO., EDDY WAVE NO.
.KEY WORDS EDDIES, COMPOUND CHANNEL

.CHANNEL TYPE EXP, THRY, COMP, SMTH

.FL 3, 3.5 M .FW 0.25, 0.185 M .FD 0.15, 0.07 M

.CL 3, 3.5 M .CW 0.07, 0.08 M .CD 0.05, 0.035 M

.FCS .Q .INST POINT GAUGE, HYDROGEN BUBBLE, CAMERA

.AUTHOR TAVOULARIS S, KARNIK U
.PUB'N J FLUID MECHANICS, VOL 204, 1989

.TITLE FURTHER EXPERIMENTS ON THE EVOLUTION OF TURBULENT STRESSES AND SCALES IN UNIFORMLY SHEARED TURBULENCE

.DATA VELOCITY FLUCTUATIONS, REYNOLDS STRESS, TURBULENT KINETIC ENERGY
.KEY WORDS TURBULENT STRESSES, STRUCTURE SCALES

.CHANNEL TYPE EXP, THRY, SIMP, SMTH, DUCT

.FL .FW 0.305 M .FD 0.45 M

.CL .CW 0.305 M .CD 0.45 M

.FCS .Q AIR .INST HOT WIRE ANEMOMETER

.AUTHOR TOMINAGA A, NEZU I, KOBATAKE S
.PUB'N HYDROCOMP 89, DUBROVNIK, YUGOSLAVIA, JUNE, 1989

.TITLE EXPERIMENTAL AND NUMERICAL INVESTIGATIONS ON TURBULENT STRUCTURE IN COMPOUND OPEN CHANNEL FLOW

.DATA SECONDARY CURRENT VECTORS, TURBULENCE INTENSITIES, TURBULENT KINETIC ENERGY, REYNOLDS STRESS
.KEY WORDS COMPOUND CHANNEL, TURBULENCE, SECONDARY CURRENTS, REYNOLDS STRESS

.CHANNEL TYPE EXP, THRY, COMP, SMTH

.FL 12.5 M .FW 0.40 M .FD 0.40 M

.CL .CW 0.20 M .CD 0.02, 0.06 M

.FCS .Q .INST LASER DOPPLER ANEMOMETER

AUTHOR TOMINAGA A, NEZU I, EZAKI K

PUB'N 23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989

TITLE EXPERIMENTAL STUDY ON SECONDARY CURRENTS IN COMPOUND OPEN CHANNEL FLOWS

DATA SECONDARY CURRENT VECTORS, ISOVELS, TURBULENCE INTENSITY, BOUNDARY & APPARENT SHEAR STRESS

KEY WORDS SECONDARY CURRENTS, COMPOUND CHANNELS, MOMENTUM TRANSFER

CHANNEL TYPE EXP, COMP, SMTH

FL 12.5 M	FW 0.4 M	FD 0.4 M
CL 12.5 M	CW 0.188, 0.2 M	CD 0.02, 0.06 M

FCS

Q

INST LASER DOPPLER ANEMOMETER, HOT FILM ANEMOMETER

AUTHOR UTAMI T, UENO T

PUB'N J FLUID MECHANICS, VOL 174, 1987

TITLE EXP. STUDY ON THE COHERENT STRUCTURE OF TURB. OPEN CHANNEL FLOW USING VISUALIZATION & PICTURE PROCESSING

DATA VELOCITY VECTORS, VORTICITY, AUTO & CROSS CORRELATION COEFFICIENTS, REYNOLDS STRESS, TURBULENCE

KEY WORDS TURBULENCE, VORTICITY, REYNOLDS STRESS, FLOW STRUCTURE

CHANNEL TYPE EXP, THRY, SIMP, SMTH

FL	FW 40 CM	FD
CL	CW 40 CM	CD

FCS

Q

INST CAMERA, DIGITIZER

AUTHOR WEI T, WILLMARTH W W

PUB'N J FLUID MECHANICS, VOL 204, 1989

TITLE REYNOLDS NUMBER EFFECTS ON THE STRUCTURE OF A TURBULENT CHANNEL FLOW

DATA TURBULENCE INTENSITY, VELOCITY, REYNOLDS STRESS, TURBULENT KINETIC ENERGY, POWER SPECTRA

KEY WORDS TURBULENCE, REYNOLDS STRESS, OPEN CHANNEL

CHANNEL TYPE EXP, SIMP, SMOOTH

FL 2.54 M	FW 0.02572 M	FD 0.3048
CL 2.54 M	CW 0.02575 M	CD

FCS

Q

INST LASER DOPPLER ANEMOMETER, MANOMETERS

AUTHOR WOOD I R, LIANG T

PUB'N J HYDRAULIC RESEARCH, VOL 27, 1989, NO 5

TITLE DISPERSION IN AN OPEN CHANNEL WITH A STEP IN THE CROSS SECTION

DATA SOURCE CONDITIONS, THEORETICAL SOLUTIONS, VELOCITY DISTRIBUTIONS, CONC., DEPTH AVERAGED CONC.

KEY WORDS DISPERSION, STEP

CHANNEL TYPE THRY, EXP, COMP, SMTH, RGH

FL 12 M	FW 0.559 M	FD
CL 12 M	CW 0.371 M	CD 0.025 M
FCS 4.7 - 60(-4)	Q 4.7 LITRES/SEC	INST PITOT TUBE, PRESSURE TRANSDUCER, CONDUCTIVITY CELL

AUTHOR WORMLEATON P R, MERRETT D J

PUB'N J HYDRAULIC RESEARCH (ACCEPTED FOR PUBLICATION 1989)

TITLE AN IMPROVED METHOD OF CALCULATION FOR STEADY UNIFORM FLOW IN PRISMATIC MAIN CHANNEL/FLOODPLAIN SECTIONS

DATA DISCHARGE, DEPTH, RELATIVE DEPTH, RADOJKOVIC INDEX, DISCHARGE ERROR, APPARENT SHEAR STRESS

KEY WORDS COMPOUND CHANNEL, FLOW DISTRIBUTION, SHEAR STRESS

CHANNEL TYPE EXP, COMP, SMOOTH, RGH

FL 56 M	FW 10 M	FD
CL 50 M	CW 1.5 M	CD 0.15 M
FCS 1.027(-3)	Q 0 - 1.1 CUMECS	INST MIN CURRENT METERS, PRESTON TUBE, POINT GAUGES, PRESSURE TRANSDUCER.

AUTHOR XINGKUI W, NING Q

PUB'N PASCE, J HYD DIV, VOL 115, NO. 6, JUNE, 1989

TITLE TURBULENCE CHARACTERISTICS OF SEDIMENT LADEN FLOW

DATA TURBULENT INTENSITY, AUTOCORRELATION COEFF, PROBABILITY & SPECTRAL DENSITY, EDDY SIZE

KEY WORDS TURBULENCE, SEDIMENT CONCENTRATION

CHANNEL TYPE THRY, EXP, SIMP, SMTH, RGH

FL 20 M	FW 0.30 M	FD 0.40 M
CL 20 M	CW 0.30 M	CD
FCS	Q	INST FLUCTUATING VELOCIMETER

.AUTHOR YOTSUKURA N, SAYRE W W

.TITLE TRANSVERSE MIXING IN NATURAL CHANNELS

.PUB'N WATER
.RESOURCES RESEARCH,
.VOL 12, NO 4,
.AUGUST, 1976

.DATA TRACER CONCENTRATION, TRANSVERSE DISTANCE, DISCH
.ARGE, GEOMETRIC PARAMETERS, TEMPERATURE DISTRIBUTION

.KEY WORDS DIFFUSION,
.MIXING, MEANDERS

.CHANNEL TYPE EXP, THRY, PROTO, SIMP, RGH, MEANDERS

.FL	.FW	.FD
.CL 5, 29 KM	.CW	.CD
.FCS	.Q	.INST

3 PRECIS OF PAPERS

The precis of papers relating to turbulence and flow characteristics in channels, ducts and pipes was compiled on the Apricot Xi-10 micro computer using Wordstar 3.40 supplied by Micro Pro.

This file indicates the aims and conclusions as detailed in the papers as well as the channel types investigated and instruments used in the experimental work.

The channel type detailed is described either as an experimental (flume), prototypical (river, irrigation canal) or theoretical (mathematical, computational) channel.

Channel form is detailed as simple; rectangular flume, channel or duct; or compound, a channel in which the geometry of the cross-section changes significantly at one particular elevation, giving rise to the discontinuity in the shape of the channel.

Smooth flumes, channels or ducts are considered to be formed of wood, steel floated concrete, glass or perspex. Rough channels are considered to be flumes and ducts with artificial roughening elements attached to the channel surface or river channels whose boundaries are considered to be naturally rough.

The aims, conclusions and details of instrumentation used are self explanatory.

ARNOLD, PASCHE, ROUVE 1985

Mixing in rivers with compound cross section

1 Experimental, theoretical, compound, smooth, rough

2 Paper describes an experimental investigation into fluvial mixing processes, with special regard to the problem of transverse mixing in channels with compound cross section and highly vegetated floodplain. Concentration profiles were measured with a video system by means of digital image processing.

3 The video technical concentration measurement system combined with digital image processing and analysis proved to be a powerful tool in the investigation of mixing processes. The usual assumptions for the lateral variation of the transverse mixing coefficient are not valid within the neighbouring zones of the fictive wall between main channel and floodplain. Comparison of turbulence intensities and turbulent diffusivities points to a dominating influence of transverse shear on the lateral mixing process in the interacting channel regions.

4 Laser Doppler Velocimeter, tracer, digital image processing.

ARNOLD, HOTTGES, ROUVE 1989

Turbulence and mixing mechanisms in compound open channel flow

1 Experimental, theoretical, compound, smooth, rough

2 Paper describes an experimental and theoretical investigation of turbulence and mixing mechanisms in compound open channels with extreme floodplain roughness.

3 Depth averaged distributions of measured Reynolds stresses clearly support the concept of subdividing the cross section of a compound channel into several zones of differently dominating turbulence mechanisms. The apparent shear stress model and the validity of wall turbulence assumptions within the so called interactive main channel

zone are physically well founded. Despite some small regions where the eddy viscosity concept fails, Boussinesque type approaches to turbulence modelling seem to be valid and appropriate for 2D flow field computations. The presented turbulence data and simplified algebraic methods of modelling the velocity, transverse diffusivity and eddy viscosity can be used to verify, initialise and speed up numerical flow field computations. With regard to a 3D treatment of the flow problem,additional investigations are necessary to back up and refine some first observations of non-isotropic turbulence conditions and secondary currents in the main channel.

4 Laser Doppler Anemometer.

ARNOLD, ROUVE, STEIN 1989

A review of investigations on compound open - channel flow

1 Theoretical, experimental, prototypical, compound, smooth, rough

2 To provide an overview for compound channel research.

3 Recent advancements (post 1985) in the experimental,analytical and numerical treatment of the flow problem are discussed and summarised, in order to show requirements for future research on compound open channel flow.

4 -

ARNOLD, STEIN, ROUVE 1989

Sophisticated measurement techniques for experimental investigation of compound open channel flow

1 Experimental, compound, smooth, rough

2 Several applications of the sophisticated measurement techniques of Laser Doppler Velocimetry and Digital Image Processing are presented in

order to discuss the advantages and problems as well as the potential for future applications.

3 The experimental results obtained from two or three channel Laser Doppler Velocimeters are extremely useful for the development and verification of flow and turbulence models. Digital image processing in conjunction with appropriate flow visualization and video type image aquisition is flexible enough to cover both velocity and concentration field measurements. Feasibility and accuracy tests based on Digital Image Processing have showed promising results.

4 Laser Doppler Anemometer, Video, Digital Image Processor

AUTRET, GRANDOTTO 1988

Finite element computation of a tuulent flow over a two dimensional backward facing step

1 Theoretical, experimental, simple, smooth, step

2 Paper deals with the numerical computation of a turbulent flow by way of a two equation model using one partial differential equation for the turbulent kinetic energy and another for the turbulent energy dissipation rate. The closure of this set of partial differential equations is then performed by algebraic relations.

3 The Galerkin finite element method predicts turbulent flow over a two dimensional backward facing step faithfully. The penalty function approach associated with the turbulence model is accurate for both the laminar and turbulent conditions of flow. Numerical reattachment length is underestimated until constant is applied which relates reattachment to the diffusive terms of the momentum equation.

4 -

BERBEE, ELLZEY 1989

The effect of aspect ratio on the flow over a rearward facing step

1 Experimental, simple, smooth, duct

2 To investigate the effect of the spanwise width on the development of a mixing layer formed behind a step.

3 For aspect ratios of 4 and 10,the mean velocity and turbulence intensity profiles are constant across the width of the test section for either of the Reynolds numbers considered, but there are significant differences among the cases studied. At a distance greater than three step heights downstream of the step, the peak turbulence intensity is greater for a higher aspect ratio and is relatively insensitive to Reynolds number. The peak frequency is lower and the spectrum is narrower for a higher aspect ratio in the region near the step.

4 Laser Doppler Velocimeter

BOOIJ 1989

Depth averaged k-e modelling

1 Theoretical, experimental, compound, smooth

2/3 Paper presents a modified depth averaged k-e model in which a more correct weighting is applied to the turbulence produced by the horizontal velocity gradients and the presence of the channel bottom.

4 -

BOZZANI, MOLINARO, ANDREOLA, STROBINO 1989

Mathematical modelling of transport and dispersion of pollutants in rivers. An experience at ENEL.

1 Theoretical, prototypical, simple, rough

2/3 Paper presents a mathematical model for the 1D simulation of the advection and dispersion of pollutants in rivers. Model applied to a real life problem and verified against measurements.

4 -

CHAPMAN, KUO 1983

Application of a high accuracy finite difference technique to steady, free surface flow problems

1 Theoretical, simple, smooth, expansion

2 Paper applies the QUICK differencing technique to the solution of the depth integrated equations of motion for steady, free surface flow in a wide, shallow, rectangular channel with and without an abrupt expansion.

3 Results show that it is possible to obtain stable,monotonic solutions to advective free surface flow problems without having to resort to implicit or explicit numerical smoothing. Comparison of the one dimensional water surface profile computation with the Runge-Kutta calculation suggests that the QUICK technique is both stable and accurate.

4 -

CHAPMAN, KUO 1985

Application of the two equation k-e turbulence model to a two dimensional steady, free surface flow problem with separation

1 Theoretical, experimental, simple, smooth, expansion.

2 Paper presents a test application of the depth integrated k-e turbulence clore model for separated flow in a wide, shallow, rectangular channel with an abrupt, symmetric expansion in width. The numerical technique employed is the spatially third order accurate QUICK finite difference method of Leonard. The performance of the depth integrated k-e turbulence closure model is evaluated by comparison of numerical results with experimental measurements of flow past a rearward facing step.

3 Numerical problems associated with the use of upwind and central differencing for convection have been overcome by the adaption of the spatially third order accurate QUICK finite difference method. The standard depth averaged k-e turbulence model results in significant underprediction of the non-dimensional reattachment length. Adaption of the depth averaged k-e model by streamline curvature correction produces an improvement in model predictions.

4 -

CHATWIN, SULLIVAN 1982

The effect of aspect ratio on longitudinal diffusivity in rectangular channels

1 Experimental, theoretical, simple, rough

2 To consider the value of logitudinal diffusivity in turbulent flow in a flat bottomed channel of large aspect ratio.

3 Value of Taylors longitudinal diffusivity for laminar flow in a channel of rectangular cross section is a about eight times the parallel plate diffusivity for large values of aspect ratio, where the parallel plate diffusivity is the value of longitudinal diffusivity obtained by ignoring all variation across the channel. Paper concludes with a discussion of the practical effects of aspect ratio on longitudinal dispersion in channels whose cross section is approximately rectangular.

4 -

CHAUDRY, BHALLAMUDI 198~~9~~8

Computation of critical depth in symmetrical compound channels

1 Theoretical, experimental, prototypical, compound, smooth

2 Paper presents a general definition of Froude number based on the one dimensional, unsteady momentum and continuity equations. Computational procedures are then outlined to determine the number of possible critical depths in a compound channel and to compute their values.

3 An equation is derived for computing the critical depth in a symmetrical channel with flood plains. An efficient algorithm is presented for calculating all the possible critical depths for a given channel and discharge.A method is presented to design a compound channel section so that there is only one critical depth.

4 -

CHEIN, CHUNG, TROUTT 1989

Momentum transport in a turbulent mixing layer

1 Theoretical, experimental, simple, smooth

2 Paper describes application of discrete vortex method for the simulation of a two dimensional plane mixing layer. Paper also describes global

features of the mixing layer and also concentrates on features such as the local instantaneous turbulent momentum fluxes and instantaneous turbulent fluctuating velocity components.

3 Numerical simulation confirms previous investigators work showing that the bulk of the turbulent momentum flux at the outer extremities of the mixing layer appears to be constructed from a series of infrequent large amplitude spikes. On the low speed side of the mixing layer these large infrequent fluxes are caused exclusively by high momentum fluid transported downward from the high speedside, and that low momentum fluid entering the high speed side also affects the turbulent flux in the high speed region. Fluctuating activities are out of phase between the low and high speed sides. The calculations also show a definite correlation between the passage of a large scale structure and a burst in turbulent momentum flux. The vortex pairing process in the mixing layer does not produce any special variations in the momentum flux history. The probability density functions associated with these fluctuating quantities mostly show Gaussian like distributions.

4 -

CHIU, KARAFFA 1989

A new velocity distribution equation for estimation of diffusion coefficient

1 Theoretical, experimental, simple, rough

2/3 Paper presents a new velocity distribution equation to estimate the diffusion coefficient needed in the study of pollutant transport. The equation is capable of modelling and simulating the velocity distribution and diffusion coefficient in an open channel, from the water surface down to the bed.

4 -

CHU, BABARUTSI 1989

Modelling the turbulent mixing layers in a shallow open channel

1 Theoretical, experimental, simple, smooth

2 Paper employs two versions of the depth averaged k-e model, a one component model and a two component model to calculate the flows of the turbulent mixing layers in a shallow open channel.

3 By treating the bed generated turbulence separately, and modelling the transverse component by a k-e model, the flows of turbulent mixing layers in a shallow open channel are calculated. e results are in good agreement with experimental data. The set of coefficients used in the model to calculate the bed friction influence is identical to the set used in the modelling of stable gravity stratified free shear flows. The analogy between the effects of bed friction and stable gravity stratification is remarkable. The bed friction number in shallow transverse shear flows plays the analogous role as the Richardson number in stable gravity stratified flows.

4 Hot film anemometer.

DAWKINS, DAVIES 1981

The effects of surface topography on momentum and mass transfer in a turbulent boundary layer

1 Experimental, theoretical, simple, smooth, duct

2 An approximate,conveniently applied theory with corresponding experimental data is presented concerning the changes in momentum and mass transfer produced by a ridge of small slopes in a flat surface quasi stationary turbulent boundary layer.

3 Pressure gradient generated by the ridge near its surface can be deduced from classical inviscid flow over a circular cylinder. Terms of a higher order than the square of a parameter which measures the curvature

of the ridge surface for a given flow system can be ignored. Second order terms of velocity perturbation can be neglected in the equations of mean motion.

4 Pitot tube

DEMUREN, RODI 1986

Calculation of flow and pollutant dispersion in meandering channels

1 Experimental, theoretical, simple, smooth, rough, meanders

2 Paper reviews experiments on and calculation methods for flow and pollutant spreading in meandering channels. A mathematical model is presented which takes full account of the three dimensionality of the flow and pollutant concentration fields. Model is based on the solution of the momentum equations governing the flow in the lateral, vertical and longitudinal directions with a three dimensional numerical procedure together with the continuity equation. The turbulent stresses appearing in the the momentum equations are calculated with a version of the k-e turbulence model that accounts for the streamline curvature effects on turbulence. The pollutant concentration field is subsequently obtained from a solution to its transport equation.

3 Model is tested against by application to three different meander situations. Detailed comparisons of the velocity and concentration fields show generally good agreement. The effect of streamline curvature on the turbulent mass fluxes was found to be important only in the narrow channel with a smooth bed. Bed generated turbulence appears to overrule this in the two cases of a wide channel with a smooth bed and a narrow channel with a rough bed.

4 Tracer

DJORDJEVIC, PETROVIC, MAKSIMOVIC, RADOJKOVIC 1989

Experimental tracer investigations in a compound laboratory channel

1 Experimental, compound, smooth

2 The results of tracer measurements in a compound channel, used to recognize and study certain flow phenomena and to validate and calibrate mass transport mathematical models are presented.

3 Measurements of tracer concentrations are successfully reproduced by a depth averaged mathematical model in which the constant dimensionless eddy viscosity concept has been used in the momentum equation. The observed transverseispersion coefficient is close to the value expected in rectangular channels. This indicates that the secondary currents are not significantly amplified by the specific section geometry except near the channel floodplain interface. The same can be concluded for the longitudinal dispersion coefficient.

4 -

ELLIOTT, SELLIN 1989

SERC Flood Channel Facility : Skewed flow experiments

1 Experimental, compound, smooth, rough, skew

2 The article describes experiments carried out on a skewed compound channel and was designed to prepare the way for a later examination of overbank flow in meandering channels.

3 The filament of maximum velocity occurs in the main channel section when overbank flow is present but is displaced sideways in the sense implied by the cross flow direction. For the deeper flows it almost leaves the main channel. The stage discharge curve shows that the total capacity of the cross section is reduced by an amount which diminishes as the depth increases. Maximum reduction in capacity for both the 5

and 9 degree skew channels is 12 per cent at a relative depth of 0.2. The boundary shear stress distribution shows a strong peak where the cross flow leaves the main channel and first moves over the floodplain. Away from this localised high value the higher bed shear stress occurs on the floodplain receiving flow from the main channel relative to the floodplain supplying flow to the main channel. An analysis of velocity and flow angle distribution in the main channel enables the construction of a system of secondary circulation cells in the main channel. This is found to be complex and assymetric. The momentum balance for the elements of the skew channel has enabled the apparent shear force term to be isolated from the cross flow momentum transfer term due to the transverse net flow across the longitudinal interfaces. The apparent shear force term is relatively more important at low depth ratios while the cross flow component appears to repress it at higher depths.

4 Miniature current meters, Preston tube, directional vanes.

ERVINE, JASEM 1989

Flood mechanisms in meandering channels with floodplain flow

1 Theoretical, experimental, compound, smooth, rough, meander

2 Paper presents a brief summary of work on meandering channels with overbank flood plain flow.

3 At present unable to predict the stage discharge relationship for a meandering river with overbank floodplain flow. This is because bed friction is not the only source of energy dissipation,but the complex shearing between main channel and flood plain flows needs to be included in the form of turbulence terms not related to bed shear. Idealised tests with floodplain flow passing over a slot in the channel bed have revealed new data on the energy loss in such a system, and also the recirculating velocity distribution in the sudden expansion region. Test with skewed main channel/floodplain system have shown that the method of computing discharge by sub-dividing a channel-floodplain by imaginary walls,produces erroneous results,the error often being of the

order of 30 per cent. Test with skewed main channel/floodplain system show that floodplain flow passing over the main channel generates recirculation regions, where the recirculating (or transverse) velocity is around 5 per cent of the longitudinal velocity,when the skew angle is 6 degrees.

4 Point gauges, miniature current meter, directional vane.

FUJISAKI, TANIGAWA, AWAYA 1989

On the dispersion phenomena of suspended solid in turbulent open channel flow.

1 Theoretical, experimental, simple, smooth

2 To study the longitudinal dispersion of suspended particles in a turbulent open channel flow.

3 Numerical solutions of the theoretical work show reasonable agreement with the experimental data. Special attention has been directed to the effect of the settling of particles on the dispersion phenomena. The virtual velocity and the dispersion coefficient of the sediment cloud are given as a function of the fall velocity parameter of particles and the bed absorbency coefficient.

4 Turbidity meter, Conductivity meter.

FODEMSKI, VOKE, COLLINS 1987

Flow simulation in channels with distorted geometry using a spectral code with co-ordinate transformation.

1 Theoretical, experimental, simple, smooth, rough

2 Paper reports a new code to simulate turbulence modelling using the spectral methods of Orszag, but also incorporating a novel generalized co-ordinate transformation approach.

3 Analysis and code successfully applied to give large eddy and direct simulations of turbulent flow in smooth plane channels, either smooth or with two dimensional surface distortions. Results from smooth channels compare well with published data, and those for distorted geometries include satisfactory predictions of circulating flows.

4 -

FUJISAKI, TANIGAWA, AWAYA 1988

On the dispersion phenomena of suspended solid in turbulent open channel flow

1 Theoretical, experimental, simple, rough

2 To study the longitudinal dispersion of suspended particles in a turbulent open channel flow with special attention directed to the effect of the settling of particles on the dispersion phenomena.

3 The virtual velocity and the dispersion coefficient of the sediment cloud are given as functions of the particle fall velocity parameter and bed absorbency coefficient. There is a virtual increase of the sediment cloud, when the sediment cloud flows downstream with the decrease of its concentration due to settling.

4 Turbidity meter, conductivity meter.

GEORGIEV 1989

Bed load transport in floodplain during high waters

1 Prototype, compound, rough

2 Paper presents information on sediment transport measurements made on a floodplain during a flood.

3 Bedload transport along the floodplain width is considerably affected by the slope characteristic of the hydrograph. For steep slopes the floodplain concentration is considered to be similar to the main channel concentration. The mean velocity in the vertical across the river width depends on the relation between the main channel and floodplain depths. With increasing floodplain flow depths the velocity on the floodplain has a similar value to that of the channel. For large flow depths on the floodplain the bottom shear stress is similar to that in the channel. At shallower floodplain depths the difference in bottom shear values between channel and floodplain increases.

4 Level recorder, current meter, sediment trap

GIBSON, RODI 1989

Simulation of free surface effects on turbulence with a Reynolds stress model

1 Theoretical, experimental, simple, smooth, rough

2 The paper presents calculations obtained with model transport equations for the Reynolds stresses,which allow for a more realistic description of the diffusion processes.

3 Anisotropy of the turbulence in the layers below the free surface in open channel flow can be adequately predicted with a Reynolds stress model containing surface effect terms in the model for the pressure strain correlation. The much greater reduction in the pressure strain mechanism in the surface layers, effectively to zero at the surface,can be accounted for without any change in the surface effect model. The model automatically leads to much larger values of the surface proximity function, which is a function of the ratio of turbulent length scale to distance from the surface and was defined to be near unity in near wall flow, in the surface layers. A zero gradient boundary condition for the length scale determining dissipation rate equation suffices to obtain fairly good predictions of the turbulent energy at the surface.

4 -

HACKMAN, RAITHBY, STRONG 1984

Numerical predictions of flows over backward facing steps

1 Theoretical, experimental, simple, smooth, step

2 Paper attempts to obtain sufficiently accurate solutions to the backward facing step problem such that the performance of the k-e turbulence model can be evalted with an added degree of confidence.

3 Predictions presented show good agreement with experimental measurements, the agreement being considered to result from the reduction of the error in solving the differential equations. Study suggests that it is not feasible to use upstream differencing to obtain accurate solutions for recirculating turbulent flows. The skew hybrid upstream differencing scheme yielded virtually grid independent results with relatively coarse meshes.

4 -

HASEGAWA 1989

Universal bank erosion coefficient for meandering rivers

1 Theoretical, prototypical, simple, rough, meanders

2 Paper uses the equation of sediment continuity to derive a semi theoretical relation for the bank erosion rate.

3 A relation for the rate of bank erosion,and thus channel shift, was derived from the equation of sediment continuity, accounting for the various processes known to be associated with bank erosion. The final result indicates that the erosion rate should be proportional to the near bank excess streamwise flow velocity. An appropriate estimate of the scouring parameter allowed for the determination of a relatively high correlation between the erosion rate and the value of the near bank excess streamwise flow velocity. Sequential maps of river platform can

be used to estimate a value of the scouring parameter based on phase shift, that optimises the correlation between the erosion rate and the near bank excess streamwise velocity. The general bank erosion coefficient and the bank erosion coefficient under flood conditions decrease as the penetration test value for the bank material increases.

4 -

HESLOP, ALLEN 1989

Turbulence and dispersion in larger U.K. rivers

1 Prototypical, simple, rough

2 Paper describes field measurements used to provide the environmental parameters for further development of a random walk model of contaminant dispersion.

3 Cross stream fluctuations tend to be slightly larger than the vertical ones. The cross stream fluctuations tend to increase on the outside of bends. The mean cross stream velocities showed changes in direction across the bend sections. Preliminary results also indicate higher turbulence values in both the vertical and cross stream directions near the bed,and the downstream traces do show significant fluctuations from the mean. The turbulence velocities across a straight section are fairly uniform. Considered that the existing 2d random walk model will simulate dispersion in straight sections of a river reasonably well, although possibly requiring the addition of a dead zone component and allowance for downstream fluctuations. However, for meandering sections the model will need to be extended to 3d to allow for variations in turbulence not only vertically and downstream, but also across the river.

4 Electromagnetic current meter

HUANG 1989

The velocity profile formula along section of open channel flow determined by the law of maximum rate of energy dissipation

1 Theoretical, experimental, simple, rough.

2 Paper presents a formula of velocity profile along section of open channel flow determined by the law of maximum rate of energy dissipation.

3 Calculations based on the proposed formula are close to the measured data. Analysis shows that the mixing length depth ratio varies from 1 at the channel bed to 0 at the surface of flow. Considered that no von Karmans constant, k = 0.4 exists even near the viscous sublayer.

4 Pitot tube

HYDRAULICS RESEARCH LIMITED 1988

International Conference on River Regime

Contains sections on :

Analytical and empirical approaches to river regime
Field and laboratory studies
Influences on river morphology
Selected papers on :

River regime

HEY et al; JULIEN; YANG; THORNE et al; WILSON; NOUH; CLARK et al; CHANG; DIPLAS et al; STRUIKSMA et al; LAMBERTI; BETTESS eal; NAKAGAWA et al.

Field and Laboratory studies

KLAASSEN et al; HERBERTSON et al; CHEE et al; MAIZELS; SUZUKI et al; HO; HIGGINSON et al; FLINTHAM et al; FUJITA et al; LEE et al.

Influences on river morphology

NEILL et al; ACKERS et al; SCHEUERLEIN; ROOSEBOOM et al; JORDAAN et al; KORNIS et al; GARRAD et al; GAVRILOVIC; BAPAT; LEWIN et al.

IMAMOTO, ISHIGAKI 1989

Secondary flow in compound open channel

1 Experimental, compound, smooth

2 The paper discusses the relation between the distribution of turbulent shear stress and that of mean velocity.

3 The lateral distribution of mean velocity near the boundary is closely related to the turbulent shear stress, and indicates the existence of secondary flow. Based upon the distribution of the turbulent shear stress it is possible to calculate the local maximum and minimum value of the velocity. Strong secondary flows were recorded from the vicinity of the edge of the floodplain, with a weaker secondary flow welling up from the edge of the floodplain to the water surface. The weaker cell is intermittent and associated with its development are secondary cells in the direction of flow.

4 Miniature current meter, hot film anemometer, hydrogen bubbles, tracer, camera

IMAMOTO, ISHIGAKI, NISHIDA 1989

Turbulence, secondary flow and boundary shear stress in a trapezoidal open channel

1 Experimental, simple, smooth

2 Paper discusses the relation between the secondary flow and boundary shear stress along the side wall of a channel based on an experimental investigation.

3 Secondary flow made visible in cross section by the use of neutrally bouyant tracer. The flow structure near the side wall of the channel is characterised by the secondary flow cells whose scales are nearly equal to the flow depth. These cells are circular and appear intermittently. Although the number of secondary flow cells is the same for each case, the scale of the cells is related to the shape of the channel cross section. Secondary flow affects the distribution of the boundary shear stress. The distribution becomes wavy as the side slope becomes gentle. Considered that if the secondary flow is neglected when calculating the flow in a trapezoidal open channel, the resistance to flow may be underestimated.

4 Preston tube, camera, video

JOHANSSON, HENRIK ALFREDSSON 1982

On the structure of turbulent channel flow

1 Experimental, theoretical, simple, smooth, duct

2 Hot film measurements of the streamwise velocity component were carried out in a fully developed turbulent water channel flow for three different Reynolds numbers.

3 Measurements of the first four statistical moments at three Reynolds numbers are presented that complement and extend the results of previous turbulent channel flow studies. The intermittent character of the short time variance of the streamwise velocities were similar at all Reynolds numbers studied. Separation of the two types of events, accelerations and retardations, makes the conditional averages collapse for a wide range of threshold levels if the velocity is scaled with the square root of the long time average of the turbulent energy from the u component. The retardations have a duration typically several times as large as that of the accelerations. The number of events decreases exponentially with the threshold level, and the events with large amplitude nearly always correspond to accelerations. The frequency of occurrence and the duration of the events scale with outer variables in the outer region of flow.

4 Laser Doppler Anemometer, Hot film probe.

JUNGSONG, SHUDONG 1989

Experimental research on flow structure and movement of suspended sediment of overbank flow (in Chinese)

1 Experimental, compound, rough

KASTRINAKIS, ECKELMANN 1983

Measurement of streamwise vorticity fluctuations in a turbulent channel flow

1 Experimental, theoretical, simple, rough, duct

2 A new vorticity probe is described. Probe is used to measure streamwise vorticity fluctuations in a fully developed turbulent channel flow.

3 The distributions of skewness and flatness factors and of rms values for the velocity fluctuations over the channel half width measured with the new probe for all three components are in good agreement with distributions published in the literature. Also, the three correlation coefficients relating the streamwise component of vorticity to the fluctuating components of velocity are measured to be zero, as expected. The strong increase of the flatness factor with wall distance indicates a strongly intermittent character for the streamwise component of vorticity in this region. The flatness factor shows values similar to those for the three fluctuating velocity components only in the vicinity of the wall,where most streamwise vortices are observed. The higher values farther away from the wall could indicate that the streamwise vortices occur sporadically.

4 Vorticity probe

KAUL, KWAK 1986

Computation of internal turbulent flow with a large separated flow region

1 Experimental, theoretical, simple, smooth, step

2 Paper describes an implicit two equation turbulence solver, in generalized co-ordinates, used in conjunction with the three dimensional incompressible Navier-Stokes solver to calculate the internal flow in a channel and a channel with a sudden 2:3 expansion. A new and consistent boundary procedure for a low Reynolds number form of the k-e turbulence model is chosen to integrate the equations up to the wall.

3 The wall boundary procedure provides better agreement with experimental data than other formulations for channel flow. Both wall function and wall boundary approaches yield results in good agreement with the experimental data for the case of a channel flow. For the case of the back step,the wall function approach used in this study yields results in a favourable comparison with the experiment, only,however,downstream of the reattachment point.

4 -

KAWAHARA, UMETSU 1986

Finite element method for moving boundary problems in river flow

1 Theoretical, prototypical, simple, smooth, rough

2 Paper presents the two step explicit finite element method used to solve the shallow water equation of river flow. The linear interpolation functions for both discharge and water elevation have been used on the three node triangular finite element. The treatment of the boundary configuration, which moves according to whether the water elevation increases or decreases,is considered.

3 Numerical illustration shows that the finite element method is entirely flexible for the analysis in which the complicated boundary configuration must be dealt with. Considered that the finite element method presented provides useful tools for the analysis of the design of river structures, improvement of floodplains.

4 -

KAWAHARA, TAMAI 1989

Mechanism of lateral momentum transfer in compound channel flows

1 Theoretical, experimental, compound, smooth, rough

2 Paper presents an attempt, using 3 dimensional calculations, to clarify the mechanism of lateral momentum transfer that determines apparent shear stress.

3 The investigation of the mechanism of lateral momentum transfer or apparent shear stress based on the 3d numerical model simulation revealed : numerical model reproduced the behaviour of the apparent shear stress under a wide variety of hydraulic conditions. The decrease of the apparent shear stress with the increase of water depth is caused through the weakness of both advection and diffusion. The increase of the apparent shears stress with the increment of flood plain roughness is mainly due to the enhancement of diffusion, though advection increases slowly. The change of the apparent shear stress with the main channel width is due to the variation of advection.

4 -

KNIGHT, SHIONO 1989

Turbulence measurements in a shear layer region of a compound channel

1 Experimental, compound, smooth

2 The paper describes some turbulence measurements undertaken on a facility representing a large scale model of a river system with flood plains, designed to produce fully developed boundary layer flows with transverse shear. The article presents some of the open channel flow data, including measurements of the primary velocity, the distribution of turbulent intensities, the kinetic energy and the Reynolds stresses in the region of strong lateral shear induced by transverse variation in depth. Attention is focussed on the non linear nature of the Reynolds stresses in the shear layer, flow structures and the lateral variations in eddy viscosity and local friction factor.

3 The vertical distributions of primary velocity are essentially logarithmic in the regions of a compound channel where the lateral shear stresses are low. In such regions, remote from the river channel/floodplain interface, the vertical distributions of Reynolds stresses are correspondingly linear. Where the logarithmic law applies, the vertical distributions of turbulent intensity and kinetic energy follow standard forms and the appropriate empirical coefficients have been determined. The spatial distributions of primary velocity, turbulent intensity, kinetic energy and the two Reynolds stresses are given for two overbank flows. In regions where there is high lateral shear superimposed on bed generated turbulence, the vertical distributions of the Reynolds stress are highly non linear. An equation is presented to describe the non linear nature of the Reynolds stress. Longitudinal vortices, generating secondary flows along the river channel/floodplain interface have been found to be important for relative depths as low as 0.25. A local force balance has been shown to be valid throughout the shear layer region. The upwelling at the river channel/floodplain interface causes considerable temporal variations in the longitudinal and lateral velocities and the lateral Reynolds stress, which in turn produce large plan form eddies that transfer momentum from the river channel to the floodplain. At low relative depths this produces the discontinuity in the stage discharge curve. The lateral variations in local friction factor for different relative depths suggest that, unlike the depth averaged viscosity, constant values may be ascribed to particular sub areas of a compound channel.

4 Laser doppler anemometer.

KNIGHT, SHIONO, PIRT 1989

Prediction of depth mean velocity and discharge in natural rivers with overbank flow

1 Theoretical, prototypical, compound, simple, rough.

2 Paper describes a theoretical model which may be used to estimate flows in rivers which flow in an out-of-bank condition and on to the adjoining flood plain.

3 The analytic solution to the depth integrated form of the Navier-Stokes equation has given reasonably close estimates of the lateral distributions of depth mean velocity in the River Severn at Montford Bridge. Calibration of the theoretical model using sub area resistance coefficients and dimensionless eddy viscosities has been shown to be relatively straight forward. Lateral integration of the depth mean velocities appears to provide a rational method for extrapolating the stage discharge curve at high flows. The underlying assumptions in the analysis are that the secondary flows are negligibly small and that the local dimensionless eddy viscosity and friction factor values vary systematically in transverse shear layers.

4 -

KOMORI, UEDA, OGINO, MIZUSHINA 1982

Turbulence structure and transport mechanism at the free surface in an open channel flow

1 Experimental, theoretical, simple, smooth

2 To investigate the turbulence structure and the transfer mechanism at and near the free surface.

3 At and near the free surface vertical velocity fluctuations are damped and so the redistribution of the energy of the vertical motion promotes the lateral and streamwise motions. Large energy containing eddies with

a size close to the integral scale of turbulence replace the free surface and control the heat and mass transfer across it. A simple surface renewal model was presented, its assumptions confirmed by the turbulence measurements; this model predicted the observed results of the liquid side mass transfer coefficients with satisfactory accuracy.

4 Laser Doppler Velocimeter, Cold film probe

KOMORI, UEDA, OGINO, MIZUSHINA 1983

Turbulence structure in stably stratified open channel flow

1 Experimental, theoretical, simple, smooth

2 To clarify the bouyancy effects on the turbulence structure in a developed stably stratified outer layer in open channel flow.

3 Bouyancy effects on the turbulence structure in the outer layer of stably stratified open channel flow have been investigated experimentally and a theoretical consideration has been added. The outer layer of the present flow is close to local equilibrium, and there the local gradient Richardson number becomes a significant parameter for representing the bouyancy effects. Turbulence quantities in stable conditions are well correlated with the Richardson number are qualitatively predicted by a spectral equation model based on two point correlation equations. In stable conditions, fluctuating motions become close to wavelike motions, and turbulent heat and momentum transfer against the mean temperature and velocity gradients occurs in strongly stable stratification. Especially, the counter gradient heat transfer in the vertical direction is remarkable, and it is due to the intermittent bouyancy driven motions : in the present flow configuration, the intermittent upward motions of the advected eddies with higher temperature than the mean temperature.

4 Laser Doppler Velocimeter, Cold film probe

KOTSOVINOS 1988

Secondary currents in straight wide channels

1 Theoretical, prototypical, experimental, simple, smooth, rough

2 To present a plausible mechanism which produces the cellular structure of the secondary currents.

3 Flow pattern of secondary currents are considered to have their origin in the variations of the normal stresses. Suggested that the Reynolds normal stresses in combination with the viscous forces over a normal section produce a flow pattern which is a result of a marginal stability mechanism. The width of the secondary flow rolls is equal to the depth of flow.

4 -

KRUGER, BOLLRICH 1989

Boundary shear distribution in rectangular and trapezoidal channels with uniform and non-uniform bed and wall roughness

1 Experimental, theoretical, simple, rough

2 Paper presents theoretical and experimental investigations on the dependence of boundary shear distribution on the shape of channel and on the roughness in rectangular and trapezoidal open channels.

3 Agrees with results of KNIGHT (1981) for smooth or uniformly rough rectangular channels. For bed to wall roughness ratio of 19.4 gained agreement with tests by KNIGHT undertaken with a bed to wall roughness ratio of 1000. Reason for same results associated with widely divergent roughness ratio put down to KNIGHT using artificial strip elements and the authors using granular materials. Derivation of a regression equation for the mean bed shear stress is confirmed by testing against experimental data from FLINTHAM and CARLING (1988). Deviations between equation values and experimental data of the order of 5 per cent.

4 Shear plate, Preston tube.

LARSSON 1989

Lateral mixing in open channels - the important processes

1 Experimental, theoretical, prototypical, simple, smooth, rough

2 Paper discusses the processes involved in lateral mixing in open channel flow

3 Considered that lateral mixing in open channel flow outside the laboratory is dominated by the process of differential advection caused by secondary currents. Estimate shows that the mass flux caused by this process is equal in magnitude to turbulent diffusive flux when the secondary velocities are typically 1 per cent of the streamwise velocity. Paper also presents three processes that may generate secondary currents of this magnitude in straight channels.

4 -

LEAN, WEARE 1979

Modelling two dimensional circulating flow

1 Experimental, theoretical, simple, rough

2 Paper looks at Reynolds stress due to bed generated turbulence, consider its relevance to scale physical models, and illustrates some of the points raised by FLOKSTRA (1977) through numerical and physical model experiments.

3 Relative significance of lateral shear stresses due to bed generated turbulence, shear layer turbulence, and secondary flow has been considered in relation to the generation of circulating flow in two dimensions. Shown under certain circumstances that the shear layer turbulence dominates lateral exchanges and the circulation can be correctly reproduced in a scale physical model, even when vertically distorted. Numerical experiments confirm the theoretical conclusions

that to produce main flow induced steady circulation requires modelling the advective momentum terms and applying a no-slip constraint at lateral boundaries. Numerical results are shown that indicate that circulation can appear in the numerical solution even when the lateral shear stress is excluded.

4 -

LI 1989

Theoretical longitudinal dispersion coefficient for natural rivers - a stochastic approach

1 Theoretical, experimental, prototypical, simple, smooth, rough

2 Paper analyses longitudinal dispersion in a stochastic framework and attempts to quantify the additional longitudinal dispersion theoretically in terms of statistical properties of river geometry ,such as mean cross sectional area, flow depth, width, their variances and variability scale.

3 The existing theory based on Taylors analysis tends to grossly under - estimate longitudinal dispersion in natural rivers due to the assumption of uniform channel cross section. The empirically based formula for predicting longitudinal dispersion coefficient do not have any generality other than those for which data are collected since the statistics of longitudinal variation of river geometry are not explicitly incorporated except in the empirical coefficients which vary from stream to stream and flow to flow. This explains why field data look so scattered when one try to fit them by empirical curve based only on mean flow and geometric quantities. By using an assumed covariance function to characterise the longitudinal variability of cross sectional area, the stochastic theory leads to a simple analytical formula that predicts the effective longitudinal dispersion coefficient. The longitudinal dispersion process in natural streams can be described as a gradient diffusion process provided that the condition of statistical homogeneity of longitudinal variation of river geometry is satisfied.

Longitudinal dispersion coefficient in natural rivers is directly related to the variability of river cross section and more importantly the scale of variability in addition to the mean flow and geometric parameters. It is the flow non-uniformity both within the cross section and in the streamwise direction that contribute importantly to the longitudinal dispersion process. Longitudinal dispersion coefficient for natural streams can be significantly higher than that for uniform open channels because of the associated large scale variability in river
cross section.

4 -

LIREN, SHU-NONG 1989

A new depth averaged two equation (k-w) turbulent closure model and its application

1 Theoretical, prototypical, simple, smooth

2 Paper describes the modification made to a new depth averaged two equation (k-w) turbulent closure model.

3 Considered that for two dimensional depth averaged simulation and prediction the two equation turlent closure model is suitable for simulating turbulent mean behaviour. The k-w model is more accurate at computing jet widths than the k-e model in the case of small outlet widths or small jet flow rates. Analysis has shown that the k-e model is not suitable for depth averaged simulation in the case of channel profile changes, since the eddy viscosity is a linear function of the water depth. In the k-w model the turbulence parameter has been replaced by the introduction of the gradient of mean field vorticity in order to model the production terms.

4 -

MANSOUR, KIM, MOIN 1988

Reynolds stress and dissipation rate budgets in a turbulent channel flow

1 Experimental, theoretical, simple, smooth

2 The budgets for the Reynolds stresses and for the dissipation rate of the turbulence kinetic energy are computed using direct simulation data of a turbulent channel flow.

3 The budget data reveal that all the terms in the budget become important close to the wall. For inhomogeneous pressure boundary conditions, the pressure strain term is split into a return term, a rapid term and a Stokes term. The Stokes term is important close to the wall. The rapid and return terms play different roles depending on the component of the term. A split of the velocity pressure gradient term into a redistributive term and a diffusion term is proposed, which should be simpler to model.

4 -

MARKATOS 1986

The mathematical modelling of turbulent flows

1 -

2/3 Paper reviews the problems and successes of computing turbulent flow. Incorporates sections on :

Field models of turbulence.
Turbulence transport models.
Recent developments and applications of two equation models.
Large eddy and full simulations.
Two fluid models of turbulence.

4 -

McKEOGH, KIELY 1989

Experimental study of the mechanisms of flood flow in meandering channels

1 Experimental, theoretical, compound, smooth, meander

2 Paper reports on a comprehensive research programme to measure velocity and turbulence in a multiple meander channel with floodplains, of sinuosity 1.25.

3 Secondary currents of appreciable magnitude are shown to exist in flood flow. In meandering flood flow, there is greater conveyance on the floodplains than on similar straight channel floodplains. The flow mechanisms of expansion/contraction analagous to pipe flow are shown to occur in meandering flood flow. Boundary shear is higher in meandering flood flow than straight channel as indicated by steeper velocity gradients close to the bed. At high floodplain depths the direction of flood flow over the meandering channel is essentially parallel with the floodplain flow.

4 Laser Doppler Anemometer.

McKEOGH, KIELY, JAVAN 1989

Velocity and turbulence measurements in a straight channel with interacting floodplains using Laser Doppler Anemometry

1 Experimental, theoretical, compound, smooth

2 Mean velocities and turbulence intensities were measured in a straight compound channel for varying floodplain depths. Results are used as a basis for qualitative descriptions of mechanisms and quantitative estimates of the momentum exchange coefficients which are used in recent simplified mathematical models for velocity distribution prediction.

3 The lateral velocity profiles for varying depth ratios show steeper gradients across the interface as the depth ratio decreases and are shown to fit exponential and power functions. Lateral turbulence intensity profiles show a variation of 5 to 10 per cent. Peak values of 10 per cent occur at the main channel interface. At the highest depth ratio of 0.5 there is almost no difference between the mean main channel and mean floodplain values of turbulence intensit. At a depth ratio of 0.29 the difference is 5 per cent. The contours of turbulence intensity show turbulence transfer from floodplain into the main channel. The calculated lateral eddy viscosity component for the main channel varies from 0.000278 m^2/s at the lowest depth ratio to 0.00046 m^2/s at the highest. Similarly the calculated lateral eddy viscosity component for the floodplain varies from 0.000016 m^2/s at the lowest depth ratio to 0.000466 m^2/s at the highest.

4 Laser Doppler Anemometer

MEULLER 1973

Turbulence measurements over a movable bed with sediment transport by laser anemometry

1 Experimental, simple, rough

2 Paper presents a first step in a study of velocities in flow with sediment transport

3 Stricklers coefficient of the bed is reduced with sediment transport. The logarithmic velocity gradient increases with sediment transport. Turbulence intensity increases proportionally to the logarithmic gradient.

4 Laser Doppler Anemometer.

MOHN, HANSCHEID, ROUVE 1987

Determination of surface roughness for simulations of natural river runoff

1 Prototypical, compound, rough

2 Paper describes investigations to demonstrate the ability of image processing algorithms to obtain data about the hydraulic roughness on floodplains of natural channels.

3 An effective data acquisition technique for the hydraulic roughness of natural channels with floodplains has been introduced. The data is stored in a digital model so that it is available for use by any kind of numerical approach. The concept of this model features the storing of data obtained by automated techniques.

4 -

MORGAN, HUGHES, TAYLOR 1977

Investigation of a mixing length and a two equation turbulence model utilizing the finite element method.

1 Theoretical, experimental, simple, smooth

2 Finite element method is used to analyse turbulent coaxial jet flow using the mixing length viscosity model.

3 Paper demonstrates that the finite element method, using simple turbulent viscosity models can be successfully employed in the analysis of both free turbulent shear flows and flows of the wall turbulence type.

4 -

MYERS, BRENNAN 1989

Flow resistance in compound channels

1 Experimental, compound, smooth

2 Results from experiments on a large scale compound channel facility are analysed to assess flow resistance characteristics of simple and compound channels having smooth boundaries.

3 Momentum transfer from main channel to floodplains has been shown to reduce significantly compound section and main channel discharge and velocity at depths above bankfull, while increasing the corresponding parameters on the floodplains. The resistance relationship obtained for the flow confined to the main channel has been shown to conform to the findings of other similar investigations, while extending previous work into a higher range of Reynolds number. Flow resistance in smooth compound channels has been presented in terms of Mannings and Darcy Weisbach resistance coefficients for the full compound shape and the main channel and floodplains calculated separately. The compound channel resistance coefficients show a significant reduction in value at depths just above bankfull, but increase to simple channel values with increasing depth. The main channel and floodplain resistance coefficients are increased and decreased respectively by the presence of the momentum transfer mechanism.

Resistance relationships for compound channels are of a more complex nature than those applicable to simple channel shapes, indicating the presence of other variables relating to the influence of the momentum transfer chanism. The occurrence of errors in the application of simple channel resistance coefficients to compound shapes has been highlighted.

4 Miniature current meters, Preston tube, point gauges.

NEZU, NAKAGAWA, RODI 1989

Significant difference between secondary currents in closed channels and narrow open channels

1 Experimental, simple, smooth, rough

2 Paper reports on a study which examines secondary currents over smooth and rough beds in narrow channels.

3 Significant difference between secondary currents in closed and open channels is discussed. A strong free surface vortex is generated by the anisotropy of turbulence due to the free surface damping effect. This vortex causes the suppression of the velocity maximum below the free surface in narrow open channel flows. On the other hand, the bottom vortex is generated by the anisotropy of the turbulence due to the side wall effect, and this vortex generates a wavy distribution of bed shear stress. The bottom vortex is affected considerably by bed roughness.

4 Laser Doppler Anemometer, hot wire anemometer.

NOKES, WOOD 1988

Vertical and lateral turbulent dispersion:some experimental results

1 Experimental, theoretical, simple, smooth

2 The results of an experimental programme designed to investigate turbulent dispersion of a continuous contaminant source in a wide channel are presented.

3 The experimental results for vertical dispersion support the use of the eigen function solution with a parabolic diffusivity and logarithmic velocity distribution. Using this method, the ideal source location for which the dilution is most rapid is well predicted. The measurements of the lateral diffusivity in the near field mixing zone and the three dimensional eigen function solution suggest that the vertical and

lateral diffusion processes are uncoupled. This implies that the lateral diffusivity distribution has the same form as the velocity distribution. The published results for lateral mixing in a long, wide channel imply that the lateral turbulent diffusivity is independent of all flow parameters except the friction factor. The shear velocity and the flow depth are confirmed as the correct velocity and length scales for both vertical and lateral turbulence in wide channels.

4 -

ODGAARD 1989

River - meander model. 1 : Development

1 Theoretical, prototypical, experimental, rough, meanders.

2 Paper describes a steady,two dimensional model of flow and bed topography in an alluvial channel with variable curvature. Model is used to describe meander flow and meander planform development.

3 Two bank erosion models are tested; the Ikeda model and the Odgaard model. The latter relates the rate of bank retreat to increase in near bank scour depth. Provides better correlation with data than the Ikeda model particularly with regard to channel migration. Analyses lead to formulas for calculation of velocity and depth distributions in meandering channels, and rate and direction of channel migration.

4 -

ODGAARD 1989

River - meander model. 2 : Applications

1 Theoretical, prototypical, experimental, rough, meanders.

2 Paper presents the results of testing a model developed in a study whose objective was to establish a guide for evaluating characteristics of meander flow and meander planform development.

3 Meander model developed can be a useful guide in the planning, design, and construction of river basin projects. Model predicts rates and direction of channel migration; magnitude and location of near bank scour as a function of flow rate. Model is based upon a linearization of the flow equations and should not be used for channels with large curvatures.

Proposed erosion model relating local rate of bank retreat to an increase in local near bank scour depth, is a viable alternative to existing theories which assume that the local rate of bank retreat is proportional to the local near bank velocity. Most uncertain feature of models are the erosion constants. Also the erosion equations are uncertain to a degree as the assumed linearity between erosion rates and flow variables has not been specifically tested. Uncertainty also exists in respect of the transverse bed slope factor, transverse mass flux factor and the sediment transport exponent in the bed load equation.

4 -

PRINOS 1989

Experiments and numerical modelling in compound open channel and duct flows

1 Experimental, theoretical, compound, smooth.

2 Paper presents a review of the experimental work undertaken in compound open channels and ducts. Recent attempts at the numerical modelling of such complex flows is described with the merits and drawbacks of each computational method applied.

3 For low relative depths, mean velocities and boundary shear stresses in the main channel or duct are overestimated by both depth averaged and 3-D models while the same flow characteristics are underestimated

on the floodplain. For high relative depths, with no significant momentum transfer effects, flow characteristics are modelled properly by both models while the 3-D model predicts the main flow features most satisfactorily. The use of an algebraic stress model in conjunction with the 3-D model predicts the complex flows present in compound open channel and duct flow with a greater degree of certainty.

4 Hot film anemometer, hot wire anemometer, Preston tube.

PRINOS, TOWNSEND 1984

Comparison of methods for predicting discharge in compound open channels

1 Experimental, theoretical, compound, smooth, rough

2 The relative accuracies of four conventional stage discharge prediction methods, for flow in compound channels, are compared in a laboratory study. Discharge measurements in a compound channel facility, along with observations from other research work, provided the basis for comparison.

3 The single channel method significantly underestimates discharge in compound open channels, especially for low relative depths of flow. The separate channels method, which subdivides the compound channel by imaginary vertical interface planes (either included or excluded in the wetted perimeter of the main channel) overestimates the discharge significantly. Subdividing the channel by horizontal interface plane, but not including this in the wetted perimeter calculation, can produce some improvement over the vertical interface plane method especially for low floodplain depths. The method based on multiple factor correlations does not seem to produce much improvement over other methods. The two methods that employ the momentum equation appear to give superior results. The accuracy of the method based on a statistical estimation of apparent shear stress, rather than using correction factors eg Karasevs method, can be improved with the development of more accurate friction factor relationships for compound channels.

4 Preston tube

PRINOS, TOWNSEND 1985

Numerical modelling of turbulent flow in compound open channels

1 Experimental, theoretical, compound, smooth, rough

2 Paper describes the depth averaged model for predicting velocity and boundary shear stress distributions in fully developed compound channel flows. The modelling of turbulent shear stress is based on the depth averaged version of the k-e model, which accounts for both bottom and free shear influences on eddy viscosity. Two algebraic turbulence models are considered, one employing a constant eddy viscosity distribution the other accounting only for wall effects.

3 Momentum transfer effects associated with flow in compound channels become significant when the velocity differential,between adjacent deep and shallow zones, is large. A modified version of the k-e turbulence model is used in the numerical modelling of compound flows in an attempt to account for momentum transfer effects. The model gave satisfactory results for compound channels with a wide main channel but was less accurate for narrow main channels. In the latter case momentum transfer effects extend over a much wider region of the compound flow field, with the result that, in general, both velocity and boundary shear stress are overestimated in the main channel and underestimated in the flood plain zones. The eddy viscosity model based on bed generated turbulence gave improved results for the flood plain portions of the the mixing regions, where the wall effect is dominant. This model was found to be inappropriate for the main channel portion of the mixing regions, where turbulence is largely governed by free shear effects.

4 Pitot tube, pressure transducer, Preston tube.

RAJARATNAM, AHMADI 1989

Three notes on hydraulics of channels with floodplains

1 Experimental, compound, smooth, meanders

2 The paper presents a method of predicting the discharge in a straight channel with floodplains using the shear layer concept. Velocity and bed shear profiles in a channel with multi-level floodplains are presented. Experimental observations on a meandering main channel with straight floodplains are also presented.

3 A method for constructing a rating curve for a compound channel is proposed. Channels with multiple floodplains can be analysed using the interaction method developed for single level floodplains. Preliminary experimental results for a meandering channel within a straight floodplain are presented. The interaction method cannot be directly applied because of the high velocity channel flow entering and running over the floodplains. The secondary flow in the meandering main channel appears to be intensified by the floodplain flow.

4 Pitot tube, yaw tube, transducer.

RASPOPIN, KOVALYOV 1989

River stream dynamics mathematical modelling in river bed and floodplain

1 Theoretical, compound, rough

2/3 Paper describes the numerical modelling of flows in channels with floodplains. Theoretical basis of the solution is based on differential flow equations involving stresses,equation of continuity, Boussinesq assumption as well as the hypothesis about linear distribution of shear stresses over the depth. For numerical realization of the model, an algorithm was proposed which is based on the implicit finite difference scheme with non-linearity of iteration.

4 -

SALIKOV 1985

Energy losses of a channel flow under conditions of overflow onto a floodplain

1 Experimental, theoretical, compound, rough, meander

2 Paper describes investigations carried out on a schematized model of a meandering river and on models of rivers with confined, free, and short circuited meanders.

3 Main types of interaction of channel and floodplain flows which are described by the equation of fluid motion with a variable discharge, were distinguished. The effect of overflow onto the floodplain on the energy losses and other characteristics of the channel flow was established.

4 -

SAMUELS 1989

The hydraulics of two stage channels - review of current knowledge

1 Theoretical, experimental, prototypical, compound, smooth, rough

2 Paper reviews the physical processes that govern fluid flow in a two stage open channel.

3 More information is required on meandering two stage channels to compliment the wide range of data available for straight two stage channels. The conveyance of a straight two stage channel should be estimated by including the interface between the main channel and the floodplain as part of the boundary of the main channel but not the floodplain. The lateral velocity equation is proposed as a method for improving the prediction of the stage discharge relationship, this relationship may be discontinuous at bank-full. The flow through a meandering two stage channel may be overestimated by up to 35 per cent

by using straight channel formulae. The area of highest velocity and bed shear may occur on the floodplain adjacent to the top of the bank in a meandering two stage channel. Care is needed when setting up 2-D depth averaged flow models of these channels. Knowledge regarding the eddy viscosity parameter needs to be improved. The friction factor for a two stage channel may show some variation with Froude number for flows just out of bank.

Natural rivers are significantly different in some key parameters from laboratory channels.

4 -

SELLIN, GILES 1989

Flow mechanisms in spilling meander channels

1 Prototical, experimental, compound, rough, meanders

2 A conceptual model is proposed for the secondary circulation system in spilling meander channels. The systematic visualisation of surface flows in the complex flow geometry studied enabled spiral flows to be identified in bend and crossover regions. This was compared with detailed velocity vector measurements already available from experiments in straight but skewed compound channels.

3 Where significant flow in a two stage channel with meanders leaves the berm to pass over the lower channel flow it would appear to determine the secondary circulation in this region. As a consequence the rows of vertically aligned vortices positioned over the lower channel banks, such a feature of the flow in straight two stage channels, appear not to be present in this case. For shallow berm flow at crossovers where there is strong crossflow, the bunching of surface streamlines indicates a zone of strong downflow although there is no evidence of actual flow reversal at the surface. At deeper flows over the berm the stronger upper channel flow dominates that in the lower channel and prevents the effects of any secondary circulation there from reaching the surface.

It is this type of flow mechanism that can generate the higher friction factor values for spilling meander channels when compared with the values from straight two stage channels.

4 Miniature current meters, directional vane, point gauges, strobe, camera.

SMITH 1989

Some aspects of floodplain flow in a valley with a meandering channel

1 Experimental, prototypical, compound, smooth, rough, meander

2 Paper describes a study of the mechanics of floodplain flow on a physical hydraulic model.

3 Model demonstrated the occurrence of a complex flow pattern when flood plain flow occurs in a valley with a meandering channel. The flow exchange process between the valley and the channel was observed to vary with stage. The net contribution of the channel flow to the total flow decreased as the stage increased above the bankfull level. Shown that the meandering channel can act as a bed load trap during a flood and, at least temporarily, may produce a higher low flow stage.

4 Point gauges

SPREAFICO, LEIBUNDGUT 1989

Travel time and transport forecasting of dissolved material within the Rhine.

1 Prototypical, theoretical, simple, rough

2 Paper presents some tracer experiments conducted on the Rhine and their contribution to the construction of a forecasting model in respect of pollution in rivers.

3 For the forecast of pollutant distributions in rivers, transport model computations are necessary as well as tracer experiments. While tracer experiments allow the measurement or the determination of all transport parameters, one dimensional computer models only predict the mean travel times. However, tracer experiments allow only the investigation of momentary flow conditions.

4 Fluorometer.

STEIN, ROUVE 1989

2D depth averaged numerical predictions of the flow in a meandering channel with compound cross section

1 Theoretical, experimental, compound, smooth, meanders

2 Paper presents a first step in the direction of calculating complex flow processes in meandering rivers with confined floodplains.

3 The model will predict water levels for named flow conditions, results of calculations showing a mean error of 2%. Because of the structure of the basic equation system, the suitability for predictions of the exact velocity distribution is not as good as for the water levels. The main tendencies of fluid motion and the reaches of fluid mass exchange between the main channel and floodplain are predicted well. A refined turbulence model should be incorporated, to improve the correspondence of the measured and calculated velocity profiles. At present the implementation of the k-e model is in progress.

Modification of the momentum disperon closure and a refined formulation of the partly constant eddy viscosities should be carried out, to test the possibility of improving the performance of the lower order turbulence simulation.

4 Laser Doppler Anemometer, point gauges, tracer.

TALMON, KUNEN, OOMS 1986

Simultaneous flow visualization and Reynolds stress measurement in a turbulent boundary layer

1 Experimental, simple, smooth

2 Flow visualization and Reynolds stress measurement were combined in an investigation of a turbulent boundary layer in a water channel. Hydrogen bubbles were used to visualize the flow; a Laser Doppler anemometer was applied to measure instantaneous Reynolds stress values.

3 Owing to the three dimensional,time dependent character of the flow it was difficult to identify flow structures from measured velocity signals, especially at larger distances from the wall. Despite this a method based on the instantaneous value of the Reynolds stress could be developed for detecting bursts in the wall region of the boundary layer. By this method the three dimensional, time dependent character of the flow is taken into account by attributing to the same burst ejections occurring successively with very short time intervals. This identification procedure is based on a comparison on a one to one basis between visualized flow structures and measured values of the Reynolds stress. The detected bursts were found to make a considerable contribution to the momentum transfer in the boundary layer.

4 Laser Doppler Anemometer, hydrogen bubbles.

TAMAI, ASAEDA, IKEDA 1986

Study on the generation of periodical large surface eddies in a composite channel flow.

1 Experimental, theoretical, compound, smooth

2 Paper describes a set of comparative experiments employed to identify a predominant factor in the generation of large eddies on the water surface at the interface between the main channel and the floodplain in a composite channel flow.

3 There exists a shear layer at the interface between the main channel and the floodplain. The most fundamental cause of the large eddies on the water surface in the interfacial zone amounts to the shear layer in a lateral velocity profile. In the interfacial zone the flow has complicated three dimensional structures. One is a strong upward flow originating from the corner of the floodplain, which is thought to be a swirl induced by the interaction between a large eddy on the water surface and the channel bed. The other is an inclined roller eddy on the floodplain bed, spreading horizontally toward the middle of the main channel. These two kinds of motion occur periodically in association with the large two dimensional eddies on the water surface. Therefore the generation frequency of large eddies on the water surface is intrinsically the same as that of large vortices in two dimensional shear layers. The periodicity of the large eddies on the water surface is explained by linear stability theory for a two dimensional free shear flow. The wave number of the large two dimensional eddies,in both an open and closed channel, is interpreted as that of the most amplified wave in the lateral shear layer at the interface.

4 Point gauge, hydrogen bubbles, camera

TAVOULARIS, KARNIK 1989

Further experiments on the evolution of turbulent stresses and scales in uniformly sheared turbulence.

1 Experimental, theoretical, simple, smooth, duct.

2/3 Paper details a study whose objectives were to expand the range of available measurements and to re-evaluate earlier results in an attempt to provide a unified view of uniformly sheared turbulence.

4 Hot wire anemometer

TOMINAGA, NEZU, EZAKI 1989

Experimental study on secondary currents in compound open channel flows

1 Experimental, compound, smooth

2 Paper describes study in which accurate turbulence measurements were conducted in compound open channel flows using both a hot film anemometer and a fibre optic laser Doppler anemometer.

3 The structure of the secondary currents in compound open channel flows is mainly composed of the floodplain vortex and the main channel vortex which are separated by the inclined upflow from the junction edge. The magnitude of the inclined upflow is greater than the secondary currents in rectangular open channel flows. When the flow depth of the floodplain is large,the distributions of the primary mean velocity are affected considerably by the secondary currents. The boundary shear stress on the floodplain is much increased by the lateral momentum transport from the main channel. The contribution of secondary currents to apparent shear stress is larger on the floodplain, whereas that of the Reynolds stress becomes with an increase of the flow depth on the floodplain.

4 Laser Doppler Anemometer, hot film anemometer.

TOMINAGA, NEZU, KOBATAKE 1989

Experimental and numerical investigations on turbulent structure in compound open channel flow

1 Experimental, theoretical, compound, smooth.

2 To investigate the primary mean flow field, turbulent structures and associated secondary currents experimentally using a fibre optic laser doppler anemometer. Numerical calculations using an algebraic stress model are compared with the experimental results.

3 Secondary currents in compound open channel flow were measured. The structure of these currents is mainly composed of the floodplain vortex and the main channel vortex which are separated by the inclined upflow from the junction between main channel and floodplain toward the free surface. The magnitude of the inclined upflow was greater than that of corner secondary currents in rectangular channels. The secondary currents become strongest for a relative depth of 0.5 with the distribution of primary mean velocities being most significantly affected by these secondary currents at this ratio. Measurement technique revealed the three dimensional structure of the turbulence intensities and Reynolds stresses. Model results were compared with numerical results from an algebraic stress model. The pattern of secondary currents was well produced. However, the magnitude and turbulence quantities were not well predicted.

4 Laser doppler anemometer.

UTAMI, UENO 1987

Experimental study on the coherent structure of turbulent open channel flow using visualization and picture processing

1 Experimental, theoretical, simple, smooth

2 Paper examines the coherent structures of turbulent open channel flow in the wall region of a channel bed quantitatively using experimental data obtained by flow visualization.

3 Successive pictures of flow patterns in two horizontal cross sections at different levels near the channel bed were taken, and then digitized and analysed by computer. This enabled the calculation of the distributions of the three components of the velocity vectors, also the distributions of velocities, streamlines, two dimensional divergence and three components of vorticity could be calculated. The idea of a two dimensional correlation coefficient is introduced in the numerical analyses, through which the degree of similarity of turbulence structures can be better estimated than with a one dimensional

coefficient. Use of the data is based upon the premise that the essential element in a turbulence structure is vortex motion. A conceptual model of the turbulence structure is proposed in which the elementary unit of coherent structure in the buffer layer is presumed to be a horseshoe vortex and in which the characteristics of the multiple structure of turbulence are shown with respect to the scale, arrangement and generating process of horseshoe vortices and longitudinal vortices. Model explains the generating mechanism and mutual relations of low speed regions,high speed regions, ejections, sweeps and localized free shear layers.

4 Camera, digitizer.

WEI, WILLMARTH 1989

Reynolds number effects on the structure of a turbulent channel flow

1 Experimental, simple, smooth

2 Paper reports on laser Doppler anemometer velocity measurements made in turbulent channel flows over a range of Reynolds numbers from 3000 to 40000.

3 Inner scaling laws of the fluctuating quantities in the inner region are Reynolds number dependent over the range examined. Near the wall, power spectra of the streamwise velocity fluctuations appear to scale with inner variables over most of the energy containing frequency range. However, at the same location, spectra of the velocity fluctuations normal to the wall and the fluctuating Reynolds stress do not scale on the inner variables in the inner energy containing frequency range. The lack of inner scaling is primarily due to increased stretching of thinner region vorticity field in the stream direction. There is also a geometry effect whereby the inner region structure from opposing channel walls interact, particularly at lower Reynolds numbers.

4 Laser Doppler Anemometer, manometers

WOOD, LIANG 1989

Dispersion in an open channel with a step in the cross section.

1 Theoretical, experimental, compound, smooth, rough.

2 Paper explores the effects of the geometry change on the dispersion of effluent.

3 Main effect observed is that releasing effluent in the deeper rather than the shallower channel gives a more rapid initial dilution. Minor effects are releasing the effluent in the deeper channel near the step leads to the maximum concentrations moving toward the step. Releasing effluent in the shallow channel near the step leads to the maximum concentration moving away from the step. The eigenvalue - eigenfunction calculation of diffusion in a stepped channel is in qualitative agreement with the measured concentration.

4 Pitot tube, pressure transducer, conductivity cell.

WORMLEATON, MERRETT 1989

An improved method of calculation for steady uniform flow in prismatic main channel/floodplain sections

1 Experimental, compound, smooth, rough.

2 Experimental results from a large scale compound channel facility are presented for discharge and boundary shear stress distribution, for sections of varying floodplain width and roughness. These are used to assess the performance of several standard discharge calculation methods which assume different locations of the interface between main channel and floodplain sub-areas.

3 Relationship developed for stage discharge curves above bank-full. Equation indicates that the discharge at very low overbank flow depths decreases as the floodplain becomes wider, suggesting an increasing degree of turbulent energy losses at the main channel/floodplain

interface. Three traditional discharge methods involving different locations of the main channel/floodplain interface were compared for four symmetrical compound sections of varying floodplain width and roughness. In terms of total discharge the diagonal interface method provided the best agreement. The vertical and diagonal interface methods improved with narrower floodplains whilst the horizontal interface is more accurate for wider floodplains. None of the methods predicted individual main channel and floodplain components accurately. Vertical and diagonal interface methods tended to overestimate the main channel flow and underestimate the floodplain flow. With increasing relative depth these errors tended to cancel, so reducing errors in total discharge. The horizontal interface method greatly underestimated the main channel discharge for higher depths. The Radojkovic indice was used to characterise the degree of interaction and momentum between main channel and floodplain sub-sections. Application of indice to the diagonal and vertical interface methods provided a significant improvement over the standard methods of discharge calculation, particularly for the individual main channel and floodplain components. Improvement was most noticeable in the case of wide and roughened floodplains. Diagonal interface in both its traditional and modified form gave better results than the equivalent vertical interface method. A simple regression equation was found relating the apparent shear stress on the vertical main channel/floodplain interface to parameters easily derived from channel geometry and roughness. This in turn enabled the Radojkovic indices to be calculated for the particular channel geometries investigated. This equation only strictly applies to the geometries from which it was derived.

4 Miniature current meters, Preston tube, point gauges, pressure transducer.

XINGKUI, NING 1989

Turbulence characteristics of sediment laden flow

1 Theoretical, experimental, simple, smooth, rough

2 Paper details experiments carried out in open channel flow in a laboratory flume, and turbulent structures of both clear water and sediment laden flow.

3 The various statistical parameters of turbulence measured in clear water are essentially consistent with data obtained by other authors. In sediment laden flow the turbulent intensity decreases with increase in concentration. In sediment laden flow,the probability density distribution and the autocorrelation coefficient are similar to those of clear water flow. Turbulent frequency decreases and turbulent energy is concentrated to large size eddies with low frequency. The longitudinal sizes of macroscale and microscale eddies increase. The results show that for a Newtonian flow with non cohesive particles, the fundamental turbulent structure has no essential change, only the turbulent intensity and frequency have some changes in magnitude. Therefore the mixing length theory can also be used to study the law governing the distribution of time average velocity for a sediment laden flow.

4 Fluctuating velocimeter

YOTSUKURA, SAYRE 1976

Transverse mixing in natural channels

1 Experimental, theoretical, prototypical, simple, rough, meanders

2 Paper presents a mathematical model for predicting the steady state two dimensional distribution of solute concentration in a meandering channel where the depth and velocity of the flow vary in both the transverse and longitudinal directions.

3 Solute concentration is a function of transverse cumulative discharge and this concept can be incorporated into the steady state two dimensional convection diffusion equation without neglecting the transverse velocity term. Using the continuity equation it is shown that the transverse velocity term is eliminated in the transformation

leading to a simpler form of mixing equation suitable for application to no nuniform channels. Adoption of an orthogonal curvilinear coordinate system based on the geometrical configuration of the channel and the flow distribution within it was found to facilitate the inclusion of effects due to channel curvature and irregularities. In particular, the scalar diffusivity concept is much more compatible with the natural coordinate system than with a rectangular Cartesian coordinate system.

4 -

4 GEOMETRIC PARAMETERS

This file detailing the dimensions of the channels studied in investigations relating to flow in open channels, ducts and pipes was compiled on the Apricot Xi-10 micro computer using Wordstar 3.40 supplied by Micro Pro.

All dimensions have been unified in S.1 units to enable comparison between individual research work.

The data is presented in three lines representing the flume dimensions, the channel dimensions and three dimensionless parameters that are considered to be representative of the channel form.

The flume dimensions enable an assessment of the size of research facility used in any particular work study and are essentially restricted to experimental facilities. Channel dimensions can relate to experimental, prototypical or theoretical investigations.

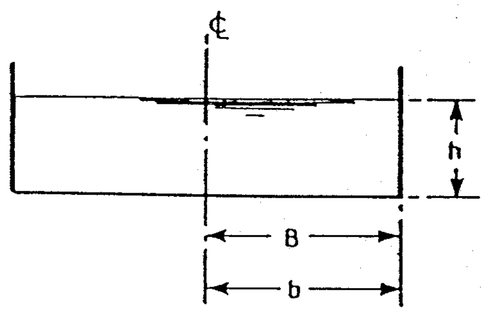
In respect of rectangular flumes or ducts the channel dimensions, with the possible exception of the length, are the same as the flume dimensions.

In respect of compound channels, the channel dimensions with the possible exception of the length, will essentially be different than the flume dimensions, as the width and depth of channel refer to the incised channel within the berms or flood plains.

Data referable to prototype research will only be found in the lines relating to channel dimensions and dimensionless parameters.

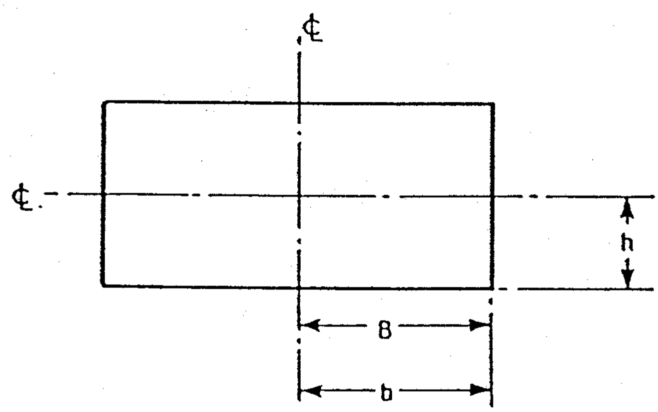
The notation used in defining the dimensionless parameters is illustrated in the diagrams a, b and c.

(a) Rectangular flume, simple channel



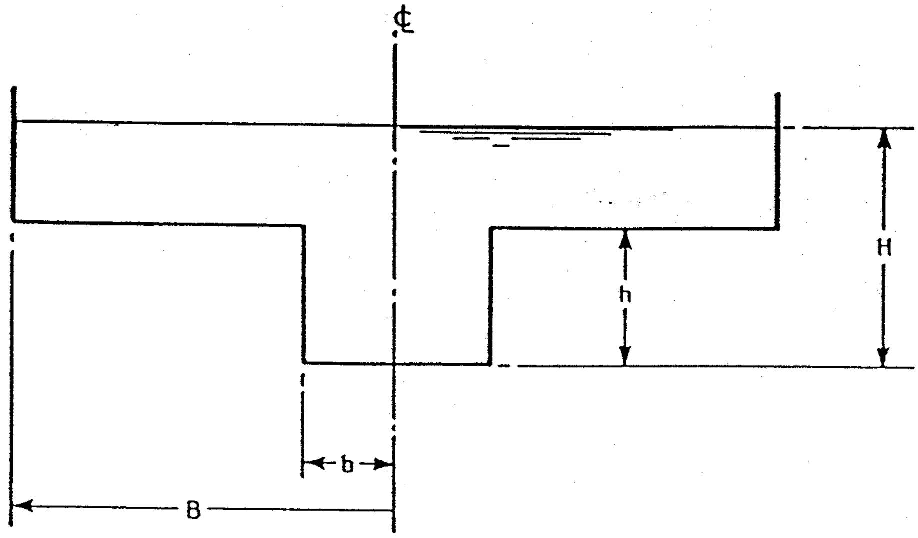
ie B/b = 1; H-h/H not applicable; b/h dependent upon flow depth.

(b) Duct - rectangular



B/b = 1; H-h/H not applicable; b/h = constant.

(c) Compound channel or duct



B/b = constant; H-h/H dependent upon flow depth; b/h = constant.

Asymmetric compound channels or ducts are treated as if representing half a complete compound channel or duct and consequently the same dimensionless parameters apply.

In respect of all channels, b, represents half the base width of the channel whether it is rectangular or trapezoidal in section.

Geometric parameters

Dimensions in metres : L = Length; W = Width; D = Depth

Ratios:

B/b = Floodplain width/Channel width
H-h/H = Flow depth - Channel depth/Flow depth
b/h = Channel width/Channel depth

where B represents half the total Floodplain width in respect of a symmetrical compound channel and b represents half the main channel width, both being related to the main channel centreline and h represents flow depth in case of rectangular channels and depth of channel below floodplain for compound channels

AUTHOR / TITLE / PUBLICATION	FLUME (M) L,W,D / CHANNEL (M) L,W,D / CHANNEL RATIOS B/b,H-h/H,b/h			SLOPE	DISCHARGE (Cumecs) / INSTRUMENTATION
ARNOLD A, PASCHE E, ROUVE G	25	1	-	-	-
MIXING IN RIVERS WITH COMPOUND CROSS SECTION					
21st IAHR CONGRESS, VOL 2, MELBOURNE, 1985	25	.314/.489	0.124		LASER DOPPLER VELOCIMETER
	2/3.2	-	2.53/3.94		DIGITAL IMAGE PROCESSING
BERBEE J G, ELLZEY J L	0.35	.1016/.254	0.075	-	AIR
THE EFFECT OF ASPECT RATIO ON THE FLOW OVER A REARWARD FACING STEP	0.35	.1016/.254	0.075		LASER DOPPLER VELOCIMETER
EXPERIMENTS IN FLUIDS, 7, 1989	1	-	2/5		
CHATWIN P C, SULLIVAN P J	-	.191/.381	-	-	-
THE EFFECT OF ASPECT RATIO ON LONGITUDINAL DIFFUSIVITY IN RECTANGULAR CHANNELS	-	.191/.381	-		-
J FLUID MECHANICS, VOL 120, 1982					
	1	-	4.05/5.44		

HASEGAWA K	-	-	-	-	-
UNIVERSAL BANK EROSION COEFFICIENT FOR					
MEANDERING RIVERS	1/4(3)	80/140	1.3/6.5		
PASCE, J HYD D, VOL 115, 6, JUNE, 1989					
	1	-	21.5/73.8		
HESLOP S E, ALLEN C M	-	-	-	-	20/43
TURBULENCE AND DISPERSION IN LARGER U.K.					
RIVERS	-	27/60	1.2/2		E.M. CURRENT METER
23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989					
	1	-	11/15		
HUANG W W L	-	2.439	- 3.4(-4)	0.0969	
THE VELOCITY PROFILE FORMULA ALONG SECTION OF					
OPEN CHANNEL FLOW DETERMINED BY THE LAW OF	-	2.439	-		PITOT TUBE
MAXIMUM RATE OF ENERGY DISSIPATION					
23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989	1	-	7.48		
IMAMOTO H, ISHIGAKI T	-	1.0	-	5.88/20(-4)	0.00032/0.0245
SECONDARY FLOW IN COMPOUND OPEN CHANNEL					
HYDROCOMP 89, DUBROVNIK, YUGOSLAVIA, JUNE, 1989	-	0.2/1.0	0.01/0.06		MINIATURE CURRENT METER
					HOT FILM ANEMOMETER
	1.4/2.5	.36/.75	1.67/20		
					HYDROGEN BUBBLES
					TRACER CAMERA
IMAMOTO H, ISHIGAKI T, NISHIDA M	13	0.39	-	1.25(-3)	0.0009/0.00568
TURBULENCE,SECONDARY FLOW AND BOUNDARY SHEAR					
STRESS IN A TRAPEZOIDAL OPEN CHANNEL	13	0.2/0.39	-		PRESTON TUBE
23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989					CAMERA
	1	-	2.5/4.8		VIDEO
JOHANSSON A V, HENRIK ALFREDSSON P	-	0.4	0.08	-	-
ON THE STRUCTURE OF TURBULENT CHANNEL FLOW					
J FLUID MECHANICS, VOL 122, 1982	-	0.4	0.08		LASER DOPPLER ANEMOMETER
	1	-	5		HOT FILM PROBE
JUNGSONG D, SHUDONG W	18	2	-	1(-3)	0.0779
EXPERIMENTAL RESEARCH ON FLOW STRUCTURE AND					
MOVEMENT OF SUSPENDED SEDIMENT OF OVERBANK FLOW	12	0.6	0.1		-
J. OF SEDIMENT RESEARCH, 1, 1989, BEIJING	1/3.33	.167/.315	2.05/3		

KASTRINAKIS E G, ECKELMANN H	9.5	0.18	1.40	-	AIR
MEASUREMENT OF STREAMWISE VORTICITY					
FLUCTUATIONS IN A TURBULENT CHANNEL FLOW	9.5	0.18	1.40		VORTICITY PROBE
J FLUID MECHANICS, VOL 137, 1983					
	1	-	0.129		
KAWAHARA Y, TAMAI N	-	-	-	-	-
MECHANISM OF LATERAL MOMENTUM TRANSFER IN					
COMPOUND CHANNEL FLOWS	-	.087/.16	.04/.05	-	
23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989					
	2/2.24	0.5	1.74/4		
KNIGHT D W	50	10	-	1.027(-3)	0/1.1
SERC FLOOD CHANNEL FACILITY - STRAIGHT					
CHANNEL DATA;SERIES 1 -13 (PROVISIONAL)	50	1.5	0.150		LASER DOPPLER
UNIVERSITY OF BIRMINGHAM, DEPT OF CIVIL					ANEMOMETER
ENGINEERING, SEPTEMBER 1989	1.2/6.67	0.05/0.5	5		MIN CURRENT METERS
					PRESTON TUBE
KNIGHT D W, SHIONO K	56	10	-	1.027(-3)	0/1.1
TURBULENCE MEASUREMENTS IN A SHEAR LAYER					
REGION OF A COMPOUND CHANNEL	50	1.5	0.15		LASER DOPPLER
J HYDRAULIC RESEARCH, VOL , NO , 1989					ANEMOMETER
	4.2	0.1/0.25	5		
KNIGHT D W, SHIONO K, PIRT J	-	-	-	2(-4)	106.5/330.8
PREDICTION OF DEPTH MEAN VELOCITY AND DISCHARGE					
IN NATURAL RIVERS WITH OVERBANK FLOW	-	17	6	-	
INT. CONF. HYDRAULIC & ENVIRONMENTAL MODELLING					
OF COASTAL,ESTUARINE & RIVER WATERS, BRADFORD,	4.8/9.4	0.07/0.231	1.417		
1989					
KOMORI S, UEDA H, OGINO F, MIZUSHINA T	6.1	0.3	0.06		LASER DOPPLER
TURBULENCE STRUCTURE AND TRANSPORT MECHANISM		-	-		VELOCIMETER
AT THE FREE SURFACE IN AN OPEN CHANNEL FLOW	6.1	0.3	-		COLD FILM PROBE
INT. J. HEAT MASS TRANSFER, VOL 25, 4, 1982	1	-	3.75		
KOMORI S, UEDA H, OGINO F, MIZUSHINA T	6.1	0.3	0.06	-	-
TURBULENCE STRUCTURE IN STABLY STRATIFIED					
OPEN CHANNEL FLOW	4.5	0.3	0.06		LASER DOPPLER J FLUID
MECHANICS, VOL 130, 1983	1	-	3.75		VELOCIMETER
					COLD FILM PROBE

KRUGER F, BOOLRICH G	28	0.25	-	1(-3)	
BOUNDARY SHEAR STRESS DISTRIBUTION IN					
RECTANGULAR AND TRAPEZOIDAL CHANNELS WITH	28	0.25	-		SHEAR PLATE
UNIFORM AND NON-UNIFORM BED AND WALL ROUGHNESS					PRESTON TUBE
23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989	1	-	.6/9		
LEAN G H, WEARE T J	32	10.4	-	-	-
MODELLING TWO DIMENSIONAL CIRCULATING FLOW					
PASCE, J HYD D, VOL 105, HY1, JANUARY, 1979	32	10.4	-	-	
	1	-	87		
McKEOGH E J, KIELY G K	14.4	1.2	0.5	-	0.0031/0.0111
EXPERIMENTAL STUDY OF THE MECHANISMS OF FLOOD					
FLOW IN MEANDERING CHANNELS	14.4	0.2	0.05		LASER DOPPLER
23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989					ANEMOMETER
	6	.167/.375	2		
McKEOGH E J, KIELY G K, JAVAN M	14.4	1.2	0.5	1(-3)	0.01 -0.036
VELOCITY AND TURBULENCE MEASUREMENTS IN A					
STRAIGHT CHANNEL WITH INTERACTING FLOODPLAINS	14.4	0.2	0.05		LASER DOPPLER
USING LASER DOPPLER ANEMOMETRY					ANEMOMETER
INT. CONF. ON HYD & ENVIRON MOD OF COASTAL,	6	0.29/0.5	2		
ESTUARINE & RIVER WATERS, BRADFORD, 1989					
MUELLER A	7	0.15	0.15	-	0.00265
TURBULENCE MEASUREMENTS OVER A MOVABLE BED					
WITH SEDIMENT TRANSPORT BY LASER ANEMOMETRY	7	0.15	-		LASER DOPPLER
15TH CONGRESS, IAHR, ISTANBUL, VOL 1, 1973					ANEMOMETER
	1	-	2.92/3.07		
MYERS W R C, BRENNAN E K	56	10	-	1.027(-3)	0/1.1
FLOW RESISTANCE IN COMPOUND CHANNELS					
J HYDRAULIC RESEARCH, VOL , NO , 1989	50	1.5	0.15		MINIATURE CURRENT METERS
					PRESTON TUBE
	1.2/6.67	0.05/0.5	5		POINT GAUGES
NOKES R I, WOOD I R	12	0.56	0.43	4.7(-4)	-
VERTICAL AND LATERAL TURBULENT DISPERSION:					
SOME EXPERIMENTAL RESULTS	12	0.56	-		
J FLUID MECHANICS, VOL 187, 1988					
	1	-	4.31/5.6		

PRINOS P EXPERIMENTS AND NUMERICAL MODELLING IN COMPOUND OPEN CHANNEL AND DUCT FLOWS HYDROCOMP 89, DUBROVNIK, YUGOSLAVIA, 1989	12.2	1.372	-	-	
	12.2	0.203/.508	0.102		HOT FILM ANEMOMETER HOT WIRE ANEMOMETER
	2.7/5.3	.134/.414	1.5		PRESTON TUBE
PRINOS P, TOWNSEND R D COMPARISON OF METHODS FOR PREDICTING DISCHARGE IN COMPOUND OPEN CHANNELS ADV. WATER RESOURCES, VOL 7, DECEMBER, 1984	12.2	1.372	-	3(-4)	0.0048/0.026
	12.2	.203/.508	0.102		PRESTON TUBE
	2.7/5.3	.09/.33	1/2.49		
PRINOS P, TOWNSEND R D NUMERICAL MODELLING OF TURBULENT FLOW IN COMPOUND OPEN CHANNELS NUMERICAL METHODS IN LAMINAR & TURBULENT FLOW, SWANSEA, 1985	12.2	-	-	3/10(-4)	-
	12.2	.102/.29	.03/.102		PITOT TUBE PRESSURE TRANSDUCER
	2.3/4.8	.164/.33	1/9.67		PRESTON TUBE
RAJARATNAM N, AHMADI R THREE NOTES ON HYDRAULICS OF CHANNELS WITH FLOODPLAINS HYDROCOMP 89, DUBROVNIK, YUGOSLAVIA, JUNE, 1989	18	1.2	0.9	-	-
	18	0.254	0.0381		PITOT TUBE YAW TUBE
	4.72	.54/.63	3.33		TRANSDUCER
SMITH C D SOME ASPECTS OF FLOOD PLAIN FLOW IN A VALLEY WITH A MEANDERING CHANNEL 23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989	22	1.2	-	8.5/10(-4)	0.0045/0.038
	-	0.122	0.076		POINT GAUGES
	9.84	.183/.468	0.8		
SPREAFICIO M, LEIBUNDGUT Ch TRAVEL TIME AND TRANSPORT FORECASTING OF DISSOLVED MATERIAL WITHIN THE RHINE 23RD CONGRESS, IAHR, OTTAWA, AUGUST, 1989	-	-	-	-	400/2400
	-	180	11		FLUOROMETER
	1	-	8.18		
STEIN C J, ROUVE G 2D DEPTH AVERAGED NUMERICAL PREDICTIONS OF THE FLOW IN A MEANDERING CHANNEL WITH COMPOUND CROSS SECTION HYDROSOFT, 1989, VOL 2, NO. 1	15	3	-	5(-3)	LASER DOPPLER ANEMOMETER
	13.7	0.4	0.1		POINT GAUGES TRACER
	7.5	.333	2		

TALMON A M, KUNEN J M G, OOMS G	2.80	1.50	0.12	-	-
SIMULTANEOUS FLOW VISUALIZATION AND REYNOLDS MEASUREMENT IN A TURBULENT BOUNDARY	2.10	0.50	-		LASER DOPPLER STRESS ANEMOMETER
LAYER J FLUID MECHANICS, VOL 163, 1986	1	-	-		HYDROGEN BUBBLES CAMERA
TAMAI N, ASAEDA T, IKEDA H STUDY ON GENERATION OF PERIODICAL LARGE	3/3.5	.25/.185	.15/.07	-	-
SURFACE EDDIES IN A COMPOSITE CHANNEL FLOW WATER RESOURCES RESEARCH, VOL 22, NO 7,	3/3.5	.07/.08	.05/.035		POINT GAUGE
1986	1/3.57	.115/.179	.7/2.64		HYDROGEN BUBBLES CAMERA
TAVOULARIS S, KARNIK U FURTHER EXPERIMENTS ON THE EVOLUTION OF	-	0.305	0.45	-	AIR
TURBULENT STRESSES AND SCALES IN UNIFORMLY SHEARED TURBULENCE	-	0.305	0.45		HOT WIRE ANEMOMETER
J FLUID MECHANICS, VOL 204, 1989	1	-	0.678		
TOMINAGA A, NEZU I, KOBATAKE S EXPERIMENTAL AND NUMERICAL INVESTIGATIONS ON	12.5	0.4	0.4	-	-
TURBULENT STRUCTURE IN COMPOUND OPEN CHANNEL	12.5	0.2	0.02/0.06		LASER DOPPLER FLOW ANEMOMETER
HYDROCOMP 89, DUBROVNIK, YUGOSLAVIA, JUNE, 1989	2	.25/.75	3.3/10		
TOMINAGA A, NEZU I, EZAKI K EXPERIMENTAL STUDY ON SECONDARY CURRENTS IN	12.5	0.39/0.4	0.4	-	-
COMPOUND OPEN CHANNEL FLOWS CONGRESS, IAHR, OTTAWA, AUGUST, 1989	12.5	0.188/0.2	0.02/0.06		LASER DOPPLER 23RD ANEMOMETER
	.5/.508	.751/.242	1.976/10		HOT FILM ANEMOMETER
UTAMI T, UENO T EXPERIMENTAL STUDY ON THE COHERENT STRUCTURE	-	0.40	-	-	-
OF TURBULENT OPEN CHANNEL FLOW USING VISUALIZATION AND PICTURE PROCESSING	-	0.40	-		CAMERA DIGITIZER
J FLUID MECHANICS, VOL 174, 1987	1	-	5		
WEI T, WILLMARTH W W REYNOLDS NUMBER EFFECTS ON THE STRUCTURE OF A	2.54	0.02572	0.3048	-	-
TURBULENT CHANNEL FLOW MECHANICS, VOL 204, 1989 MANOMETERS	2.54	0.02572	-		LASER DOPPLER J FLUID ANEMOMETER
	1	-	-		

WOOD I R, LIANG T	8	0.559	-	4.7/60(-4)	0.0047
DISPERSION IN AN OPEN CHANNEL WITH A STEP					
IN THE CROSS SECTION	8	0.371	0.025		PITOT TUBE
J HYDRAULIC RESEARCH, VOL 27, 1989, NO 5					PRESSURE TRANSDUCER
	1.507	0.51	14.84		CONDUCTIVITY CELL
WORMLEATON P R, MERRETT D J	56	10	-	1.027(-3)	0/1.1
AN IMPROVED METHOD OF CALCULATION FOR STEADY					
UNIFORM FLOW IN PRISMATIC MAIN CHANNEL/	50	1.5	0.15		MINIATURE CURRENT METER
FLOODPLAIN SECTIONS					PRESTON TUBE
J HYDRAULIC RESEARCH, VOL , NO , 1989	1/6.67	.05/.5	5		POINT GAUGES
XINGKUI W, NING Q	20	0.3	0.4	-	FLUCTUATING VELOCIMETER
TURBULENCE CHARACTERISTICS OF SEDIMENT LADEN	20	0.3	-		
FLOW					
PASCE, J HYD D, VOL 115, NO. 6, JUNE, 1989	1	-	1.5/1.67		
YOTSUKURA N, SAYRE W W	-	-	-	-	-
TRANSVERSE MIXING IN NATURAL CHANNELS					
WATER RESOURCES RESEARCH, VOL 12,	5/29 KM	-	-	1	-