

Central Board of Irrigation, India.  
Publication No. 12. (Reprint)

**DESIGN OF WEIRS**  
ON  
**PERMEABLE FOUNDATIONS**

BY

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ON

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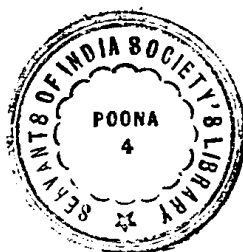
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# CONTENTS

Foreword .. .. .	(v)
Introduction .. .. .	(vi)
<b>CHAPTER I</b>	
History of Development of the Science of Subsoil Hydraulics in Relation to the Design of Weirs on Permeable Foundations .. .. .	1
<b>CHAPTER II</b>	
Theory of Seepage Flow .. .. .	8
Darcy's Law and its Extension .. .. .	8
Unsaturated Flow .. .. .	11
<b>CHAPTER III</b>	
Potential Law and its Application to the Problems of Weir Design .. .. .	12
<b>CHAPTER IV</b>	
Experimental Verification of the Potential Law by means of Models .. .. .	14
I. Mathematical .. .. .	14
II. Trial and Error or Graphical Method .. .. .	14
III. Viscous Fluid Method .. .. .	16
IV. The Hydraulic Scale Method .. .. .	17
Experimental Tank .. .. .	17
Construction of the Model .. .. .	20
Pressure Observations and Stream Lines .. .. .	20
V. Electric Analogy Method .. .. .	21
Method of Observation .. .. .	23
Comparison of Results—Models and Theory .. .. .	23
Model Characteristics in Subsoil Works .. .. .	28
i. Hydraulic Model .. .. .	28
ii. Electric Model .. .. .	28
Stratification .. .. .	29
Relative Merits of the Hydraulic and Electric Models .. .. .	29
<b>CHAPTER V</b>	
The Location and Erection of Pressure Pipes and Standard Methods of Observation and Record .. .. .	31
Geological Formation of Subsoil .. .. .	33
Location of Pressure Points .. .. .	34
Erection of Pressure Pipes .. .. .	34
Precautions to be observed in Erection of Pressure Pipes .. .. .	36
Observations and Instruments used .. .. .	37
Point of Strainer to which a Pipe Reading relates .. .. .	38
Frequency of Observations .. .. .	38
Time Lag .. .. .	38
Method of Record and Standard Forms used .. .. .	39
Plotting of Graphs .. .. .	42
<b>CHAPTER VI</b>	
Models and the Prototypes .. .. .	43
Comparison of Results .. .. .	43
Theory and Models offer safe guide for designs .. .. .	51
Seasonal variations in value of $\Phi$ .. .. .	51
Effect of Silt and Scour .. .. .	52
Effect of Temperature .. .. .	52
Temperature Effect on Models .. .. .	57
Valdianathan's Experiments .. .. .	57
Harbans Lal's Experiments with the Panjnad Model .. .. .	58
Seasonal variations in Subsoil Temperatures .. .. .	60
Seasonal variations of Silt and Temperature as influencing Stability of Works .. .. .	61
Interpretation of seasonal variations .. .. .	62
<b>CHAPTER VII</b>	
The Mathematics of Weir Design .. .. .	63
Determination of Uplift Pressures and Exit Gradients .. .. .	63
General Form .. .. .	65
Case 1. Floor with Pile Line at Downstream End with Step .. .. .	70
Case 2. Single Pile Line with Fall—No Apron Upstream or Downstream .. .. .	72
Case 3. Single Sheet Pile—Equal Fill—No Aprons .. .. .	73
Case 4. Floor with Pile Line not at end .. .. .	74
Case 5. Floor with Pile Line at end .. .. .	75
Case 6. Simple floor—No Pile Line .. .. .	76
Case 7. Depressed Floor .. .. .	78
Case 8. Floor with multiple lines of piles .. .. .	79

	Page
A. General Solution for Exit Gradient .. .. .	79
Case I. Sheet Pile at Step with Aprons .. .. .	80
Case II. Sheet Pile at Downstream End and Step .. .. .	80
Case III. Sheet Pile in unequal Filling—No Aprons .. .. .	80
Case IV. Floor with Pile Line not at End .. .. .	81
Case V. Single Sheet Pile—Equal Fill—No Aprons .. .. .	81
Case VI. Floor with Pile Line at Downstream End .. .. .	81
Case VII. Simple Floor—No Pile Line .. .. .	81
APPENDIX TO CHAPTER VII	
Mathematical Investigations of the Subsoil flow under two Standard Forms of Structures .. .. .	101
Case I. Depressed Floor without Aprons .. .. .	103
Case II. Equal Sheet Piles at heel and toe without Aprons .. .. .	104
CHAPTER IX	
Exit Gradients as Related to Weir Design .. .. .	107
Experiments with Water Flowing Downwards .. .. .	111
Experiments with Water Flowing Upwards .. .. .	112
The True Significance of Exit Gradients .. .. .	113
Factor of Safety .. .. .	114
Determination of Exit Gradients .. .. .	115
CHAPTER VIII	
Standard Forms .. .. .	117
The General Case, Stepped Floor with Pile Line at the Step or Fall .. .. .	117
Case I. Floor with Sheet Pile at Downstream End with Step .. .. .	118
Case II. Single Sheet Pile, No Aprons. Unequal fill on two sides .. .. .	119
Case III. Single Sheet Pile, No Aprons, Equal fill .. .. .	120
Case IV. Floor with Sheet Pile not at End .. .. .	120
Case V. Floor with Pile at End .. .. .	121
Case VI. Simple Floor—No Pile line .. .. .	121
Case VII. Depressed Floor—No Sheet Pile .. .. .	121
Case VIII. Floor and Multiple Sheet Pile .. .. .	122
(a) Floor with a Sheet Pile at Either End .. .. .	122
(1) End Piles Equal .. .. .	122
(2) Piles Unequal .. .. .	123
(b) Floor with Piles at Ends and Middle .. .. .	123
(c) Floor with a Pair of Piles not at the Ends .. .. .	125
CHAPTER X	
Working Rules and General Principles of Design .. .. .	129
Khosla's Method of Independent Variables for the Determination of Uplift Pressures and Exit Gradients .. .. .	129
Mutual Interference of Piles .. .. .	133
Sloping Floors .. .. .	140
The Method of Independent Variables in relation to Exit Gradients .. .. .	140
The Application of the new Method to investigate pressures under some actual weirs. .. .. .	142
Panjnad Weir .. .. .	142
Khanki Weir .. .. .	143
Deg Escape Head .. .. .	145
Lloyd Barrage .. .. .	146
Kalabagh Weir (proposed) .. .. .	147
Design of New Works .. .. .	149
Depth of scour .. .. .	149
Depth of Sheet Piling .. .. .	153
Piles at the Upstream and Downstream Ends necessary .. .. .	153
Intermediate Piling .. .. .	154
Wells .. .. .	154
Examples of Designs .. .. .	155
Floor to act as one mass .. .. .	157
The Inverted Filter .. .. .	157
Pressure Relief or Drainage .. .. .	157
Design of Flanks .. .. .	158
Strength of Sheet Piles at the upstream and Downstream ends of a weir floor .. .. .	164
Magnitude of Uplift Pressure for Design of Floor Thickness .. .. .	166
Time Lag .. .. .	166
APPENDIX TO CHAPTER X	
An empirical formula for the pressure percentages at the joins of a variable intermediate pile to a floor, which is also provided with equal end piles .. .. .	168
CHAPTER XI	
Design of Weirs in relation to Surface Flow .. .. .	169
Aflux .. .. .	169
The Effect of Construction of Weirs on the Regime of a River .. .. .	170

	Page
Effect of Regime Changes on Weir Design .. .. .	171
(a) Retrogression of Levels .. .. .	171
(b) Restoration of the original slope upstream of the weir .. .. .	171
(c) Recovery of downstream bed levels .. .. .	171
Discharge per foot run and waterway .. .. .	171
Undersluices .. .. .	172
Weir .. .. .	173
Barrage .. .. .	172
Depth of Scour and Section of Aprons .. .. .	173
Depth of Scour for Design of Aprons .. .. .	175
Length, Shape and Free-board of guide banks .. .. .	177
The Standing-Wave .. .. .	179
The Momentum Formula .. .. .	179
Standing-wave and Design of Downstream Floor .. .. .	183
Thickness of floor as determined by the Standing-wave .. .. .	184
Length of Horizontal floor as determined by the Standing-wave .. .. .	186
The Glacis .. .. .	186
Level of Downstream Floor as determined by the Standing-wave .. .. .	186
Summary of Procedure in Design .. .. .	189
Energy Dissipation and Prevention of Dangerous Scour Downstream of Aprons .. .. .	190
Failures of Dams and their Lessons .. .. .	194
Need for further Research .. .. .	194
List of Board Publications .. .. .	195
List of Sub-Committees provided by the Central Board of Irrigation .. .. .	196
INDEX .. .. .	197

Pocket containing extra copies of certain graphs mounted on lines

## FOREWORD

CENTRAL BOARD OF IRRIGATION,  
SIMLA.

The Central Board of Irrigation published in December 1934 its eighth publication under the title "Observation and record of Pressures below Works on Permeable Foundations", which was edited by Rai Bahadur A.N. Khosla, I.S.E., B.A., M.Am.S.C.E., A.M.I.E. (India). The object of that publication was, primarily, to set forth the factors involved in the design of hydraulic works on permeable foundations, the up-to-date knowledge on the subject, and the information further required for the solution of the problem. That Publication also described the methods by which further information could be acquired, and recommended the introduction of observation pressure pipes on all new works of that type. The Publication was given a wide distribution and recipients were asked to provide the Board with any information likely to prove useful in further study of the problem. Very little information has been received however, chiefly owing to the fact that few works of this nature have recently been constructed and provided with the necessary observation pipes. Fortunately, however, exhaustive investigations have been carried out by the Authors of this new Publication, with the result that they are now able to present a complete solution to the problem, which is supported by data from prototypes in the field, models in the laboratory, and by mathematical theory. The contents of this Publication are the result of an investigation in the Punjab Irrigation Department over a period of nine years, and the Board is indebted to the Punjab Members of the Board, and to the Authors, for the opportunity of publishing this valuable treatise on one of the first problems which received the attention of the Board at the time of its constitution in November 1930.

This Publication has been compiled by Rai Bahadur A. N. Khosla, who has also been responsible for the field research, for the engineering interpretation of the laboratory investigations and their application to design. The laboratory investigations at the Punjab Irrigation Research Institute have been carried out by Dr. V. I. Vaidhianatban, Dr. H. L. Uppal and Mr. J. K. Malhotra under the direction of Dr. E. McKenzie Taylor. The theory of subsoil flow and the mathematics of weir design is the work of Dr. N. K. Bose.

M. T. GIBLING,  
*Secretary,*  
*Central Board of Irrigation.*

*Dated 1st September, 1936.*

## IN TRODUCTION

The Design of Weirs on Permeable Foundations was one of the first subjects taken up for enquiry by the Central Board of Irrigation in their first<sup>1</sup> meeting in November, 1930.

The flow of water through the subsoil flow below Weirs, with its attendant hydraulic gradients and uplift pressures, has been recognised as the determining factor in design, ever since 1895, when Col. Clibborn carried out his classic experiments with Khanki sand at Roorkee. Until recently, the so-called Bligh Creep Theory—which was no more than an imperfect adaptation of Col. Clibborn's work—held the field. It has been realised, eventually that the subject is more complex than the simple formula of Bligh indicated.

After some considerable discussion at the Central Board meeting of November 1933<sup>2</sup> the following resolution was adopted unanimously:—

- (a) that further intensive study of subsoil flow beneath actual works was assential,
- (b) that in view of the active part already taken by Mr. Khosla, and his published papers on the subject, the compilation of a comprehensive note on the subject should be entrusted to him,
- (c) that Mr. Khosla should be supplied with all available observations on the subject from India,
- (d) that in order to secure uniformity of observations he should prepare a note on the nature of observations required and the form in which they should be tabulated; this note to be communicated to all interested, through the office of the Board.

In compliance with item (d) of this resolution, Rai Bahadur A. N. Khosla, I.S.E., presented a note on the Observations and Record of Pressures below Works on Permeable Foundations, which was printed in December, 1934, as Publication No. 8 of the Central Board of Irrigation.

All available copies of this Publication were soon distributed and there was demand for more. It was, at first, proposed to issue a reprint, but in view of the considerable advance that had been made, in the meantime, on the study of the subject, both in the field and in the laboratory, the Executive Committee of the Central Board resolved (20th July, 1935) to have the Publication No. 8 revised or to have a new paper written on the subject. Sir Bernard Darley in his letter No. 9453, dated the 29th July, 1935, suggested that a tentative set of rules for guidance in design be framed by Mr. Khosla and discussed at the November meeting of the Board with a view to their incorporation in the new publication. During the interval before November, the field and laboratory researches reached a stage when the final solution of the problem came within sight so that it was possible to lay down definite, and not merely tentative, rules for guidance in design. This fact along with a general review of the state of knowledge to date, was presented by Mr. Khosla<sup>3</sup> at the meeting of the Central Board held at Delhi in November, 1935. As a result of discussion of this, and in view of item (b) of the Resolution No. 7 of November, 1933, requiring the writing up of a comprehensive note on the subject, it was decided that the new publication should embody all available information on the subject in addition to the essential matter already contained in the Publication No. 8. The President stressed the necessity for the revised Publication being complete in itself and not in any way supplementary to the first addition<sup>4</sup>.

The present publication incorporates the essence of Field Research in the Punjab since 1927 and of Laboratory Research carried out at the Punjab Irrigation Research Institute since 1932—the latter, under the direction of Dr. E. McKenzie Taylor. An attempt has been made to trace from its inception the history of development of the science of subsoil hydraulics as related to the design of Weirs on Permeable Foundations. Notice has been taken of all contemporary literature within the Authors' knowledge, and any help derived from such literature has been duly acknowledged in the text.

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(1) Proceedings of the Central Board of Irrigation, first meeting, November, 1930, page 8.

(2) Minutes of the Proceedings of the 4th Annual Meeting of the Central Board of Irrigation held in Lahore, 13-15 November, 1933, page 12.

(3) Appendix II, Central Board of Irrigation. Publication No. 11, Annual Report 1934-35.

(4) Publication No. 11, page 50.



The publication has been divided into a number of self-contained Chapters. Of these Chapter VI is more or less a reproduction of the relevant matter in Publication No. 8. The remaining Chapters contain mostly new matter. The entire mathematics has been collected in one Chapter, No. VII. Chapter VIII, on exit gradients, deals with some fundamental principles in design.

The Plates, Diagrams, Equations and Tables in each Chapter bear the number of that Chapter in addition to their own distinctive numbers. Thus Plate VII. 6 indicates Plate No. 6 of Chapter VII. Similarly Equation No. 10. 2 indicates Equation No. 2 of Chapter X.

Every effort has been made to make the publication complete in itself, so that designs can be worked out in complete detail without much reference to outside literature. The incorporation in Chapter XI, of the essential diagrams relating to Energy of Flow and Standing Wave, originally prepared by Messrs. Montagu and Crump and modified to suit special problems by Mr. Kanwar Sain, will considerably facilitate the work of the designer.

While it can now be claimed that the design of Weirs on sand foundations in relation to flow of water through the foundation soil can be determined with great exactness in a rational and scientific manner from the simple rules given in Chapter X, its determination in relation to flow over the surface still depends mainly on empiricism. This latter aspect of the subject is dealt with in Chapter XI and calls for further intensive study in the field and more particularly in the Laboratory.

#### *Acknowledgments*

Dr. Vaidhianathan, Head of the Physics Section, Punjab Irrigation Research Institute, developed the technique of the Electrical Method used for determination of uplift pressures. The Authors are indebted to him and to his Assistant, Mr. Gurdas Ram, for the valuable investigations that they have carried out in connection with this paper.

The Authors are also indebted to Mr. Harbans Lal of the Hydraulics section for the investigation he carried out on the Hydraulic Models, the results of which form an essential part of this paper.

The Authors wish to thank Bhai Naranjan Singh, Subordinate, for the careful observations and record of field data at Panjuad and Khanki.

The Authors are indebted to Mr. A. Murphy, O. B. E.; Mr. J. B. G. Smith C. I. E. and Sir Bernard Darley, Kt., C.I.E., whose keen interest in the subject has been of very material assistance, and to Messrs. Kanwar Sain, Montagu and Haigh, for their valuable suggestions in Chapters X and XI.

# INDEX

	Pages		Pages
<b>A</b>			
Abutments, design of .. .. .	158	Design of weirs, working rules and general principles .. .. .	129
Afflux, consideration of, in the design of weirs .. .. .	169	Design of weirs, summary of procedure in .. .. .	189
Afflux, at various weirs in Punjab .. .. .	170	Designs, examples of .. .. .	165
Angle of repose .. .. .	161	Discharge per foot run and water way .. .. .	171
Application of new method to investigate pressures under some actual weirs .. .. .	142	Discharge and scour, relation between .. .. .	151
Aprons, sections of, and depth of scour .. .. .	173	Discharge temperature, and viscosity, relative values of .. .. .	53
Arrows for dissipation of energy .. .. .	192	Dissipation of energy and prevention of scour .. .. .	190—192
<b>B</b>			
Baffle walls, for dissipation of energy .. .. .	192	Downstream floor, design of, and standing wave .. .. .	183
Banks, guide, design of .. .. .	177	Downstream floor, level of as determined by the standing-wave .. .. .	186
Barrage, definition of .. .. .	173	Downstream piles .. .. .	164
Bell sounder .. .. .	37	Drainage, or pressure relief .. .. .	157
Bernoulli's equation .. .. .	12	Dynamic impact factor in weir design .. .. .	169
Bligh's creep theory .. .. .	2	<b>E</b>	
Blocks and arrows for dissipation of energy .. .. .	192	Electric analogy method, comparison of results, models and theory .. .. .	23
Borings for determination of strata .. .. .	33	Electric analogy method, description of .. .. .	21
<b>C</b>			
Capillaries, movement of water in .. .. .	8	Electric analogy method, method of observation in .. .. .	23
Cavity under Khanki Weir .. .. .	107	Electric and hydraulic models, comparison of results .. .. .	43
Christoffel and Schwarz's method of conformal transformation .. .. .	13, 65	Electric and hydraulic models, relative merits of .. .. .	29
Clibborn's experiments .. .. .	1	Electric model .. .. .	28
Colman's experiments .. .. .	3	Energy, dissipation of .. .. .	100—192
Comparison of results—in model and theory .. .. .	23	Energy of flow curves .. .. .	187
Complex section of weir, split up into elementary forms for design .. .. .	131	Examples of designs .. .. .	155
Creep theory, Bligh's .. .. .	2	Exit Gradient .. .. .	76, 129, 149
"    Lane's, weighted .. .. .	6	Exit Gradient, determination of .. .. .	115
Crest level, determination of, for a weir .. .. .	173	Exit Gradient, general solution for, by J. K. Malhotra .. .. .	79
Critical gradient .. .. .	4	Exit Gradient, method of independent variables in relation to .. .. .	140
Curvilinear square method, Forchheimer's .. .. .	14	Exit Gradient as related to weir design .. .. .	107
<b>D</b>			
Dams, failures of, and their lessons .. .. .	194	Exit Gradient, the true significance of .. .. .	113
Darcey's law and its extension .. .. .	8	Exit Gradient and uplift pressures, mathematical determination of .. .. .	63
Darcey's law of flow of water through permeable soils .. .. .	1	Experimental tank .. .. .	17
Deg Diversion, pressures under floors .. .. .	50	Experimental verification of the potential law by means of models .. .. .	14
Deg Escape Head, investigation of pressures under .. .. .	145	<b>F</b>	
Deg Escape Head, and its model, comparative results of .. .. .	50	Factor of safety .. .. .	114
Densities of sands .. .. .	109	Failures of different weirs, causes of, etc. 149, 194 .. .. .	149, 194
Dentated sill, Rehbock's .. .. .	192	Failures of weirs from seepage flow .. .. .	107
Depressed floor .. .. .	78, 101	Filter, inverted .. .. .	157
Depressed floor, no sheet pile .. .. .	121	Flanks, design of .. .. .	158
Depressed floor without aprons .. .. .	103	Floor to act as one mass .. .. .	157
Depth of scour, determination of .. .. .	149	Floor, depressed .. .. .	78, 101
Depth of scour and section of aprons .. .. .	173	Floor, depressed, no sheet piles .. .. .	121
Depth of sheet piling .. .. .	153	Floor, depressed, without aprons .. .. .	103
Design of abutments .. .. .	158	Floor, downstream, design of and the standing wave .. .. .	183
Design of downstream floor and standing wave .. .. .	183	Floor, downstream, level of, as determined by the standing wave .. .. .	186
Design of flanks .. .. .	158	Floor, horizontal, length of, as determined by the standing wave .. .. .	186
Design of glacis .. .. .	186	Floor, simple, no pile line .. .. .	76, 81, 121
Design of new works .. .. .	149	Floor, sloping .. .. .	140
Design of weirs in relation to surface flow .. .. .	169	Floor, stepped, with pile line at the step or fall .. .. .	117

	Pages
Floor thickness as determined by the standing wave .. .. .	185
Floor thickness, magnitude of uplift pressure for design of .. .. .	166
Floor with multiple lines of piles .. .. .	79, 122
Floor with a pair of piles not at the ends .. .. .	125
Floor with pile line at downstream end .. .. .	81
Floor with pile line at downstream end with step .. .. .	70, 118
Floor with pile line at end .. .. .	75, 121
Floor with pile line not at end .. .. .	74, 81, 89, 90, 120
Floor with piles at ends and middle .. .. .	123
Floor with a sheet pile at either end .. .. .	122
Flotation gradient.. .. .	4, 107, 109, 113
Floor, surface, design of weirs in relation to .. .. .	169
Flow, two dimensional, equation of .. .. .	13
Flow, unsaturated .. .. .	11
Forchheimer's curvilinear square method .. .. .	14
Forms, standard, for recording data .. .. .	39
Forms, standard, of weirs .. .. .	117
Foundation wells .. .. .	154
Frequency of pressure observations .. .. .	38

## G

General form of flow .. .. .	65
Geological formation of sub-soil .. .. .	33
Glacis, design of .. .. .	186
Glacis, inclined, standing wave on .. .. .	181
Gradient, critical .. .. .	4
Gradient, exit .. .. .	6, 149
Gradient, exit, determination of .. .. .	115
Gradient, exit, general solution for, by J. K. Malhotra .. .. .	79
Gradient, exit, method of independent variables in relation to .. .. .	140
Gradient, exit, as related to weir design .. .. .	107
Gradient, exit, the true significance of .. .. .	103
Gradient, exit, and uplift pressures, mathematical determination of .. .. .	63
Gradient, flotation .. .. .	4, 107, 109, 113
Gradient, hydraulic, theory of .. .. .	2
Graphical method of verification of potential law .. .. .	14
Graphs of data of readings of different pressure pipes, plotting of .. .. .	42
Guide bank aprons .. .. .	174
Guide banks, design of .. .. .	177

## H

Harbans Lal's experiments with Panjnad model .. .. .	58
Horizontal floor, length of as determined by the standing wave .. .. .	186
Hydraulic and electric models, comparison of results .. .. .	43
Hydraulic and electric models, relative merits of .. .. .	29
Hydraulic gradient, theory of .. .. .	2
Hydraulic jump .. .. .	179
Hydraulic scale model .. .. .	17
Hydraulic scale model, construction of .. .. .	20
Hydraulic scale model experimental tank .. .. .	17
Hydrostatic pressure on abutments and wing walls .. .. .	161

## I

Impact, dynamic, in design of weirs .. .. .	169
Inclined glacis—standing wave on .. .. .	181
Independent variables—method for the determination of uplift pressures .. .. .	129

	Pages
Independent variables, method of, in relation to exit gradients .. .. .	140
Induced stratification .. .. .	55
Instruments used, and observations, for pressures .. .. .	37
Interference, mutual, of piles .. .. .	133
Intermediate piling .. .. .	154
Inverted filter .. .. .	167

## K

Kalabagh Weir, proposed, application of new method to investigate pressures under .. .. .	147
Khanki Weir, application of new method to investigate pressures under .. .. .	142, 143
Khanki Weir, arrangement of arrows and blocks .. .. .	193
Khanki Weir, cavity under .. .. .	107
Khanki Weir, comparative statement of pressures on models and prototype .. .. .	50
Khanki Weir, hydraulic gradients under floor .. .. .	51
Khanki Weir, location of pressure pipes .. .. .	33
Khanki Weir, pressures on flanks .. .. .	158
Khanki Weir, pressures under floor .. .. .	43
Khanki Weir, variation in temperature of river and sub-soil water .. .. .	61

## L

Lane's weighted creep theory .. .. .	6
Law of flow of water through permeable soils, Darcey's .. .. .	1
Location of pressure points .. .. .	34
Lloyd Barrage, application of new method to investigate pressures under, Lloyd Barrage and its electric model, comparative results of .. .. .	146
Lloyd Barrage, pressures under floor .. .. .	50

## M

Mathematical investigation of the sub-soil flow under two standard forms of structures .. .. .	101
Mathematical solution for the determination of weir profile .. .. .	14
Mathematics of weir design .. .. .	63
Method of independent variables for the determination of uplift pressures .. .. .	129
Method of independent variables in relation to exit gradients .. .. .	140
Merala Weir, scour under .. .. .	149
Merala Weir, uplift due to unbalanced head at trough of standing wave .. .. .	180
Model characteristics in sub-soil work .. .. .	28
Model, electric .. .. .	28
Model, experimental verification of the potential law by .. .. .	14
Model, hydraulic, construction of .. .. .	20
Model, hydraulic and electric, relative merits of .. .. .	29
Model and prototypes, comparison of results .. .. .	43
Model, temperature effect on sub-soil pressures in .. .. .	57
Model and theory as a guide for design of works .. .. .	51
Momentum formula for standing wave .. .. .	179
Movement of water in capillaries .. .. .	8
Mutual interference of piles .. .. .	133

	Pages
Observations and instruments used for pressures .. .. .	37
Observations, method of .. .. .	23
Observation of pressures, frequency of ..	38

## P

Panjnad Weir, application of the new method to investigate pressures on ..	142
Panjnad Weir, downstream scour on model of .. .. .	149
Panjnad Weir, effect of temperature and silt on uplift pressures .. .. .	52
Panjnad Weir, location of pressure pipes .. .. .	34
Panjnad Weir model, hydraulic gradients under, at different temperatures of inflowing water .. .. .	58
Panjnad Weir, pressure pipes, facts established from full scale experiments ..	5
Panjnad Weir, pressures on the flanks ..	158
Panjnad Weir, pressure under floor ..	43
Panjnad Weir, stream lines under model of .. .. .	21
Panjnad Weir, temperature effect on pressures .. .. .	60
Panjnad Weir, uplift pressures, comparative statement of model and prototype .. .. .	44
Pavlovsky's experiments .. .. .	3
Permeable soil, flow of water through, Darcy's Law .. .. .	1
Permeability of various silts, sands and fine gravels .. .. .	54
Pile line, single, with fall, no apron upstream or downstream .. .. .	72
Pile sheet, at downstream end and step ..	80
Pile sheet, at step with apron .. .. .	80
Pile sheet, inunequal filling, no aprons ..	80
Piles, mutual interference of .. .. .	133, 168
Piles, necessary at the upstream and downstream ends .. .. .	153
Piling, intermediate .. .. .	154
"Piping" .. .. .	107
Pitching, stone, thickness of .. .. .	174
Plotting of graphs of data of pressure pipes .. .. .	42
Poiseuille's law .. .. .	1
Pore space .. .. .	109, 113
Porosity, values of, for sands and soils ..	54
Potential function .. .. .	10
Potential law and its application to the problems of weir design .. .. .	12
Potential law, experimental verification by means of models .. .. .	14
Potential law, limitations of .. .. .	11
Pressures along a pile line, comparison of pressures distribution, causes of deviation from normal .. .. .	56
Pressures, distribution of, on standard forms of weir .. .. .	117
Pressure distribution under floors with different slopes .. .. .	140
Pressure, effect of silt and temperature on Pressure observations and stream lines ..	20
Pressure percentages at the joins of a variable intermediate pile to a floor, which is also provided with equal end piles .. .. .	168
Pressure pipe observations, frequency of ..	38
Pressure pipes, erection of .. .. .	34
Pressure pipes, erection of at different headworks .. .. .	32
Pressure pipes, location of at Khanki ..	33

## Pages

Pressure pipes, location of at Panjnad ..	33
Pressure pipes, observations and instruments used .. .. .	37
Pressure pipes at Panjnad, facts established from the full scale experiments ..	5
Pressure pipes, precautions to be observed in erection of .. .. .	36
Pressure pipes, record method and standard forms used .. .. .	39
Pressure points, location of .. .. .	34
Pressure relief or drainage .. .. .	157
Pressure on sloping floors .. .. .	140
Pressure types met with in designing the abutments and wing walls of hydraulic structures .. .. .	158
Pressure under floor, Deg Diversion Head ..	50
Pressure under floor, Khanki Weir .. .. .	43
Pressure under floor, Lloyd Barrage .. ..	50
Pressure under floor, Panjnad Weir .. ..	43
Pressure under some actual weirs, application of the new method to investigate the .. .. .	142
Pressure, uplift, effect of silt and scour ..	51, 52
Pressure, uplift, effect of temperature of flowing water .. .. .	52, 60
Pressure, uplift, and exit gradients, determination of .. .. .	63
Pressure, uplift, magnitude of, for design of floor thickness .. .. .	166
Pressure, uplift, the method of Independent variables for the determination of ..	129
Pressure, uplift, on the weir floor .. ..	129
Principles, general, and working rules of weir design .. .. .	129
Prototypes and models, comparison of results .. .. .	43, 51
Punjab sands, experiments with .. .. .	110

## R

Recovery of downstream bed levels .. ..	171
Regime changes, effect of, on weir design ..	171
Regime of a river, effect of construction of weirs on .. .. .	170
Rehbock's dentated cill .. .. .	192
Rehbock's experiments .. .. .	4
Research, need for .. .. .	194
Restoration of the original slope upstream of the weir .. .. .	171
Retaining walls, design of .. .. .	158
Retgression of levels .. .. .	171
Rules, working, and general principles of weir design .. .. .	129

## S

Sands, Punjab, experiments with .. .. .	110
Sands, specific gravity, pore space, transmission constants, and flotation gradient ..	113
Schaffernak's conclusions on stratification work .. .. .	29
Schlichter's theoretical treatment of sub-soil flow .. .. .	9
Schwarz and Christoffel's method of conformal transformation .. .. .	13, 65
Scour, classification of .. .. .	152
Scour, dangerous, prevention of, downstream of aprons .. .. .	190
Scour, depth, determination of .. .. .	149
Scour, depth, and section of aprons .. ..	173
Scour and discharge, relation between ..	151
Scour and silt, effect of, on pressures ..	52
Seasonal variation of P/H percentage .. ..	51

	Pages		Pages
Seasonal variations of pressures, interpretation of ..	62	Trimmu Weir (proposed), profiles of standing waves and hydraulic gradient lines for various discharges ..	183
Seasonal variations of silt and temperature influencing stability of works ..	61	Trimmu Weir (proposed), showing effect of reduction in length of downstream floor ..	187
Seasonal variations in sub-soil temperatures	60	Two dimensional flow, equation of ..	13
Seepage flow, failure from ..	107		
Seepage flow, theory of ..	8	<b>U</b>	
Sheet piles, equal, at heel and toe without aprons ..	104	Undersluices ..	172
Sheet piles, strength of, at the upstream and downstream ends of a weir floor ..	164	Unsaturated flow ..	11
Sheet piling, depth of ..	153	Uplift pressures ..	149
Sherman Island Dam, variation of uplift, head and water temperature under ..	61	Uplift pressures, effect of silt and scour ..	51, 52
Silt and scour, effect of, on pressures ..	52	Uplift pressures and exit gradient, determination of ..	63
Silt and temperature, effect of, on pressures on Panjnad Weir ..	52	Uplift pressures, magnitude of, for design of floor thickness ..	166
Silt and temperature, seasonal variations of, as influencing stability of works ..	61	Uplift pressures, method of independent variables for the determination of ..	129
Slope original, upstream of the weir, restoration of ..	171	Uplift pressures on the weir floor ..	129
Sloping floors ..	140	Upstream piles ..	164
Specific gravity of sand ..	113		
Stability of works, influence on, by seasonal variations of silt and temperatures ..	61	<b>V</b>	
Standard forms for recording data ..	39	Vaidhianathan's experiments ..	57, 110
Standard forms of weirs ..	117	Variations, seasonal, in pressures, interpretation of ..	62
Standing wave, ..	179	Variations, seasonal, of silt and temperature as influencing stability of works ..	61
Standing wave, calculations for ..	180	Variations, seasonal, in sub-soil temperature ..	60
Standing wave, and design of downstream floor ..	183	Variations, seasonal, in value of P/H percentage ..	51
Standing wave, profile of ..	187	Velocity of water in sands and soils ..	54
Stone in aprons, analysis of, in relation to discharge per foot run ..	176	Viscosity, temperature and discharge, relative values of ..	53
Stone pitching, thickness of ..	174	Viscous fluid method, for stream lines ..	16
Strainer, point to which a reading of the pressure pipe relates ..	38	Vortices, erosive and accretive ..	191
Stratification ..	29		
Stratification induced ..	55	<b>W</b>	
Stream lines, determination of ..	16	Walls, retaining, design of ..	158
Stream lines, and pressure observations ..	26	Walls, wing, design of ..	158
Sub-soil flow, mathematical investigations of ..	101	Waterway and discharge per foot run ..	171
Sub-soil flow, theoretical treatment by Schlichter ..	9	Weaver's general case ..	74
Sub-soil flow, under two standard forms, mathematical investigation of ..	101	Weaver's mathematical treatment of the flow of water through permeable sub-soils under dams ..	5
Sub-soil geological, formation of ..	33	Weighted creep theory, Lane's ..	6
Sub-soil temperatures, seasonal variations in ..	61, 62	Weirs, causes of failure ..	149, 194
Sub-soil work, model characteristics in ..	28	Weirs, choice between shutters and counterbalanced gates ..	173
Summary of procedure in weir design ..	189	Weirs, design, exit gradient related to ..	107
Surface flow, design of weirs in relation to ..	169	Weirs, design, mathematics of ..	63
		Weirs, design, in relation to surface flow ..	169
<b>T</b>		Weirs design, summary of procedure in ..	189
Temperature effect on models ..	57	Weirs, design, working rules and general principles of ..	129
Temperature effect on pressures ..	55	Weirs, determination of crest level of ..	173
Temperature and silt effect on uplift pressures on Panjnad Weir ..	52	Weirs, effect of construction of, on regime of a river ..	170
Temperature and silt, seasonal variations influencing stability of works ..	61	Weirs, failure from seepage flow ..	107
Temperature, sub-soil, seasonal variations in ..	60, 61	Weir, Kalabagh (proposed) application of the new method to investigate pressures under ..	142, 147
Temperature, viscosity and discharge, relative values of ..	53	Weir, Merala ..	149
Theory and models offer safe guide for design of works ..	51	Weir, Panjnad, application of the new method to investigate pressures under ..	142
Thermometres, different types of ..	37	Weirs, section, complex, splitting up into elementary forms for design purposes ..	131
Time lag in pressures ..	38, 146	Wells, foundation ..	154
Transmission constant ..	1, 54, 113	Wing walls, design of ..	158
Trial and error or graphical method of verification of potential law ..	14	Working rules and general principles of design ..	129
		Works, new, design of ..	149

This Pocket contains the following illustrations :—

- |                |               |
|----------------|---------------|
| 1. Plate VII—5 | 5. Plate X—3  |
| 2. Plate VII—6 | 6. Plate XI—1 |
| 3. Plate X—1   | 7. Plate XI—2 |
| 4. Plate X—2   |               |