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"HYDROELASTIC EXCITATION OF CYLINDERS"

*Thesis submitted for the
Degree of Doctor of Philosophy*

- at the -

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The University of Auckland
New Zealand*

- by -

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July, 1971

ACKNOWLEDGEMENTS

The work for this Thesis was carried out under the supervision of Professor A.J. Raudkivi, to whom the author expresses appreciation for his encouragement and his invaluable advice.

The assistance and financial support of the New Zealand Railways and the interest shown in the project by the Engineering Staff is gratefully acknowledged.

In addition the author wishes to thank -

Associate Professor R.A. Callander for hours of useful discussion.

Mr. H.B. Gatland, Senior Lecturer in Electrical Engineering for the design of electronic equipment.

Messrs. E.S.D. Fleming, J.M.B. Brown, and A.P.J. Matthias of the Workshop, who built the equipment.

Messrs. D.N. Browne, C. Raymond, Laboratory Technicians, who assisted with the experiments.

Mr. C. Collins for the photography.

Mr. M.D. Scott and his Library Staff.

Mr. F.N. Kirton and Purchasing Office staff.

Mrs. G. Margetts for her excellent work in typing this Thesis.

Among those who contributed most are my parents and fiancée, and I thank them for their continuing encouragement and patience shown at all times during my studies.

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NOTATION

a	lateral spacing of vortex trail
a_1	moment lever arm
A	projected area of body on plane normal to body movement
A_c	calibration coefficient
A_L	linearizer constant
B_c	calibration constant
B_L	linearizer constant
B_i $i=1,7$	constant
c	damping coefficient of cylinder
c_f	damping factor
c_w	damping coefficient of near wake
C	radial distance from cylinder centre to external vortex
C_D	drag force coefficient
C_F	lift coefficient perpendicular to free stream
C_{FO}	lift coefficient perpendicular to free stream for $\alpha = 0$
C_L	lift force coefficient
C_S	skin friction drag coefficient
C_T	transverse force coefficient
$C_{Fy}(f)$	cospectral function
d	half length of near wake
D	diameter of cylinder
exp	exponential function
E	elastic modulus

E_w	work
f_d	driving frequency
f_n	fundamental natural frequency
f_{on}	fundamental natural frequency in vacua
f_r	frequency ratio
f_s	frequency of vortex shedding
f_{wc}	wake coupling constant
f'_{wc}	dimensionless wake coupling constant
F	resultant force
F_{Bi} $i=2,4$	buffetting forces
F_{Dy}	transverse component of instantaneous drag force
F_{MVS}	maximum force due to vortex shedding
F_R	total force acting on pier
F_{VS}	vortex shedding force
F_w	wake force
F_x	force component in streamwise direction
F_y	force component in transverse direction
$F(z)$	complex potential function
F_1	velocity component of wake force
F_2	displacement component of wake force
F_3	velocity component of drag force
F_4	displacement component of drag force
g	acceleration due to gravity = 32.2 fps ²

$G_{Fy}(f)$	cross spectral function
$ G_{Fy}(f) $	modulus of cross spectral function
h	longitudinal spacing of vortex street, width of near wake
i	= $\sqrt{-1}$ imaginary quantity
i_c	= current
I	moment of inertia
I_w	moment of inertia of near wake
k	mechanical spring constant
k_l	a constant
k_w	angular spring constant of near wake
K	virtual mass coefficient
K_l	a constant
K_L	linearizer constant
K_α	a factor relating velocity ratio and circulation
l	point along length of a structure
L	length of structure
L_*	modified length of structure
m	mass of structure
m_l	mass of structure per unit length
m_L	linearizer exponent
M	number of piles in road
M_B	bluffness ratio
M_x	moment of body at point x on its length

n	an integer
n_L	linearizer exponent constant
N	number of rows of piles
P	pressure
P_f	in phase force coefficient
P	force
P_i $i=1,2$	constant
q	resultant velocity
q_f	quadrature force coefficient
Q	quadrature force
$Q_{Fy}(f)$	quadspectral function
R	constant
Re	Reynolds Number
R_f	resistance of film
R_w	resistance of film at fluid temperature
s	constant
S	Strouhal number
S^*	Roshko's wake Strouhal number
S_i $i=1,2$	material stresses
t	time
t_{li}	time for vortex to travel from point 1 to point i
t_s	period of vortex shedding
T	torque

u	velocity in streamwise direction
U_s	free stream line velocity
U_∞	upstream velocity
v	velocity in transverse direction
V_c	critical flow speed
V_r	reduced velocity
V_R	resultant velocity
V_{out}	output voltage from anemometer
V_{LIN}	output voltage from linearizer
V_s	speed of vortex
w	complex velocity
x	streamwise or horizontal coordinate axis
y	transverse or vertical coordinate axis
Y	amplitude of oscillation
Y_o	half amplitude of oscillation
Y_{STAT}	half amplitude of oscillation due to static loading
z	complex number
Z	reduced amplitude (Y/D)
Z_o	reduced half amplitude (Y_o/D)
Z_s	section modulus
α	wake angle
α_e	effective wake angle
α_{eM}	value of effective wake angle at mid amplitude

α_M	maximum value of wake angle
α_{MO}	maximum value of angle of approach of relative velocity
α_o	angle of approach of relative velocity
$\bar{\alpha}$	maximum wake angle with respect to centre of gravity of wake
β	velocity ratio
Γ	circulation
δ_a	fluid dynamic logarithmic decrement
δ_s	logarithmic damping decrement of structure
δ_i $i=1,2$	phase angles
Δ	deflection of structure
ϵ	percentage of flow energy in vortex
ϵ_i $i=1,2$	phase angle
θ	phase angle between force and displacement
κ	vortex strength
λ_i $i=1,4$	roots of characteristic equations
μ	dynamic viscosity
ν	kinematic viscosity
π	3.1416
ρ	density of fluid
ϕ	phase angle
ψ	stream function
ω	vorticity function
ω_n	fundamental angular frequency of structure
ω_v	angular frequency of wake or vortex shedding