ENGINEERING HANDBOOK

structural design

section 6

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

PREFACE

This handbook is intended primarily for the use of Soil Conservation Service engineers. Much of the information will also be useful to engineers in other agencies and in related fields of work.

The aim of the handbook is to present in brief and usable form information on the application of engineering principles to the problems of soil and water conservation. While this information will generally be sufficient for the solution of most of the problems ordinarily encountered, full use should be made of other sources of reference material.

The scope of the handbook is necessarily limited to phases of engineering which pertain directly to the program of the Soil Conservation Service. Therefore, emphasis is given to problems involving the use, conservation, and disposal of water, and the design and use of structures most commonly used for water control. Typical problems encountered in soil and water conservation work are described, basic considerations are set forth, and all of the step-by-step procedures are outlined to enable the engineer to obtain a complete understanding of a recommended solution. These solutions will be helpful in training engineers and will tend to promote nation-wide uniformity in procedures. Since some phases of the field of conservation engineering are relatively new, it is expected that further experience may result in improved methods which will require revision of the handbook from time to time.

The handbook material has been prepared by M. M. Culp, Head of the Engineering Standards Unit of the Engineering Division, and his associates, Woody L. Cowan and Carroll A. Reese, under the general direction of the Engineering Council. The Council is made up of the regional engineers and the Chief of the Engineering Division at Washington. Under its direction the needs of engineers in all parts of the country have been considered and are reflected in the subject matter selected, the method of presentation, and the organization of the different sections.

Many sources of information have been utilized in developing the material. Original contributions and verbatim use of previously published materials are acknowledged in the text.

Engineering Council:

T. B. Chambers, Chairman
W. S. Atkinson
A. Carnes
Edwin Freyburger
J. J. Coyle
C. J. Francis
J. G. Bamesberger
Karl O. Kohler, Jr.

CONTENTS - SECTION 6

STANDARD DRAWINGS

SECTION 6

A = effective tension area of concrete per bar;
= area;
= coefficient.

A_b = area of individual reinforcing bar.

a = height of vertical slab fixed on three edges;
= distance from end of beam to concentrated load;
= ratio of distance from end of beam to start of partial uniform load to total beam span.

b = width of compression face of member;
= breadth or width of vertical slab fixed on three edges.

b_c = breadth of conduit.

b_d = breadth or width of ditch or trench at top of conduit.

C = coefficient $[k(1 - k)] \div 2$ (see ES-1);
= ratio of load intensities, $q_2 \div q_1$, (see ES-3);
= ratio of stiffnesses, $K_s \div K_w$, (see ES-28 and ES-29).

C_c = coefficient (see page 6.2-22 and ES-22).

C_d = coefficient (see page 6.2-18 and ES-15).

D = nominal diameter of bar
= $k(1 - k^2)$ (see ES-3).

d = effective depth of section;
= distance between two concentrated loads (see ES-25).

d_b = nominal diameter of bar.

d_c = thickness of concrete cover to center of bar closest to extreme fiber.

E = $3 \div (1 + k)$ (see ES-3).

e = 2.7183 = base of Naperian logarithms;
= eccentricity;
= moment arm.

f_c = compressive stress in concrete.

f'_c = compressive strength of concrete.

f_s = stress in reinforcement.

f'_s = stress in compressive flexural reinforcement.

f_t = tensile stress in plain concrete.

f_y = yield strength of reinforcement.

H = height of wall;

= vertical distance from top of fill to top of conduit;

= vertical distance between center lines of top and bottom of conduit (see ES-28 and ES-29);

= horizontal component of force.

H_c = vertical distance from top of fill to top of conduit.

H_e = height of equal settlement.

h = vertical dimension or distance (see ES-4);

= vertical inside dimension of conduit (see ES-28 and ES-29).

i = angle of surcharge between fill slope and horizontal.

j = ratio used in reinforced concrete relations.

K = ratio of active lateral pressure to vertical pressure;

= a shape factor coefficient for wind loads.

K_s = stiffness of slab (see ES-28 and ES-29).

K_w = stiffness of wall (see ES-28 and ES-29).

k = radius of gyration;

= ratio of distance from end of beam to a point on the beam to total span length.

L = distance between center lines of vertical walls of rectangular conduit (see ES-28 and ES-29).

ℓ = horizontal inside dimension of conduit (see ES-28 and ES-29);

= length of beam.

ℓ_d = development length.

M = moment.

M_{ab} = moment at end "a" of member "ab."

M^F_{ab} = fixed end moment at end "a" of member "ab."

M^S_c = simple beam moment at point "c."

$M_{k\ell}$ = moment at distance $k\ell$ from end of beam.

M_x = $M_{k\ell}$ where $x = k\ell$.

m = (see ES-29).

N = direct force.

n = modular ratio of steel to concrete;

= (see ES-29).

P = resultant active force per foot of wall (see page 6.2-4);

= concentrated load.

P_H = horizontal component of P.

P_V = vertical component of P.

P_p = resultant passive force per foot of wall (see page 6.2-15).

p = intensity of pressure at a point;
= (see ES-28).

p_n = normal unit pressure on inclined surface.

psf = pounds per square foot.

psi = pounds per square inch.

q = intensity of load on a beam;
= (see ES-28).

R = resultant of a system of forces on loads;
= reaction.

R_A = reaction at end "A" of beam.

R_A^F = reaction at end "A" of fixed ended beam.

R_A^S = simple beam reaction at end "A."

S = shear.

U_A^F = algebraic sum of fixed end moments at joint "A."

u = bond stress.

V = vertical component of force;
= wind velocity;
= shear.

v = shear stress in concrete.

v_c = allowable shear stress taken by concrete.

V_A = shear at end "A" of structural member.

V_A^F = shear at end "A" of fixed ended member.

V_A^S = shear at end "A" of simply supported member.

$V_{k\ell}$ = shear at distance $k\ell$ from end of member.

W = total load on a beam.

W_c = total load per unit of length on a conduit.

w = specific weight of soil per unit volume;
= weight of equivalent fluid per unit volume.

x = coordinate length (usually horizontal).

y = coordinate length (usually vertical).

Z = factor associated with flexural crack width;
= angle of friction between soil and back of wall.

z = ratio of lengths or distances.

α = $(2K\mu') \div b_d$ (see page 6.2-17).

γ = unit weight of backfill (see ES-15 and ES-22).

δ = settlement deflection ratio (see ES-22).

θ = angle between horizontal and inclined surface;

= angle between horizontal and back face of wall.

μ = tangent of angle of internal friction in backfill.

μ' = tangent of angle of friction between fill material and the sides of the ditch or trench.

ρ = projection ratio.

ρ_t = steel ratio for temperature and shrinkage reinforcement.

Σ = summation sign -- sum of.

Σo = perimeter of tensile reinforcement.

ϕ = angle of internal friction of a soil.

Additional symbols and notations used in reinforced concrete design discussions conform to those given in the "Reinforced Concrete Design Handbook" of the American Concrete Institute.