DAfStb H. 617 - Part 4.1:

Attachment 4.1-1: Notation and Formulary for the ACI-DAfStb Shear Database vsw-RC-A for the evaluation of reinforced concrete beams with stirrups subjected to point loads

Nr. (no.)			running number,
Lit. (Author)			reference: author, year
Bez. (Test specimen)			specimen as named by author

Einheiten (Units): dual input in Imperial units or SI - units; Imp. units are converted into SI-units, and all calculations in SI-units.

Querschnittswerte (section properties)

b	b	[in → mm]	width of flange
bw	b_w	[in → mm]	width of web
h	h	[in → mm]	height of beam
hf	h_f	[in → mm]	height of flange
hh,top	$h_{h,top}$	[in → mm]	height of top haunch
hw	h_w	[in → mm]	height of web
hft	h_{ft}	[in → mm]	height of tension flange
hh,bot	$h_{h,bot}$	[in → mm]	height of botton haunch
bft	b_{ft}	[in → mm]	width of tension flange
Ac	A_c	[mm^2]	gross area of concrete section
zc2	z_{c2}	[mm]	distance of CGS from top fibre

Laststellung und Geometrie (loading and geometry)

aa	a_a	[in → mm]	dimension of support plate
af	a_f	[in → mm]	dimension of loading plate

ba	b_a	[in → mm]	distance between support axis and beam end
L	L	[in → mm]	span
c	c	[in → mm]	distance between point loads
a	a	[in → mm]	distance of point load from support axis
kap	a/d	[-]	moment - shear force - ratio

<u>Längsbewehrung (Zugbewehrung) (longitudinal tension reinforcement)</u>

cc	c_c	[in → mm]	minimum concrete cover
ds	d_s	[in → mm]	effective depth of reinforcing bars
Stab_Z	Stäbe	[-]	number and diameter of bars
ns	n_s	[-]	number of bars
dst	$\varnothing_{st}$	[in → mm]	average diameter
fR	f_r	[-]	r = ribbed bars; 0=plain bars
As	A_s	[in² → mm²]	area of reinforcing steel for long. reinf.
alphaa	α_a	[-]	coefficient for anchorage (hook 0.7; straight 1.0; anchor plate 0.01)
rhos	$\rho_s = \frac{A_s}{b \cdot d} \cdot 100$	[%]	geometrical reinforcement ratio
rhosw	$\rho_{sw} = \frac{A_s}{b_w \cdot d} \cdot 100$	[%]	geom. reinforcement ratio related to web width
fsy	f_{sy}	[ksi → MPa]	yield strength of longitudinal steel
esy	$\varepsilon_{sy} = \frac{f_{sy}}{E_s}$	[‰]	yield strain (for E_s = 200.000 MPa)

ftk	f_{tk}	[ksi → MPa]	tensile strength
ftk/fsy	f_{tk}/f_{sy}	[-]	ratio
euk	ε_{uk}	[‰]	steel strain at tensile strength f_{tk}

<u>Längsbewehrung (Druckbewehrung) (longitudinal compression reinforcement)</u>

Stab_D	Stäbe	[-]	number and diameter of bars
ds2	d_{s2}	[in → mm]	distance of compress. reinforc. from compress. edge
ns2	n_{s2}	[-]	number of compr. bars
dst2	$\varnothing_{st2}$	[in → mm]	average diameter of compr. bars
As2	A_{s2}	[in² → mm²]	area of compr. bars
fsy2	f_{sy2}	[ksi → MPa]	yield strength of compression bars

<u>Bügelbewehrung (stirrups)</u>

dw	$\varnothing_{w}$	[in → mm]	diameter of stirrups
nsw	n_{sw}	[-]	number of stirrup legs
Asw	A_{sw}	[in² → mm²]	area of stirrups
frw	f_{rw}	[-]	r = ribbed bars; 0=plain bars
sw	s_{w}	[in → mm]	spacing of stirrups in long direction
sw / h	s_{w}/h	[-]	ratio
sw / d	s_{w}/d	[-]	ratio
zw1	z_{w1}	[mm]	inner lever arm defined by stirrup height
zw2	z_{w2}	[mm]	inner lever arm defined by concrete cover

rhow	$\rho_w = \frac{A_{sw}}{s_w \cdot b_w} \cdot 100$	[%]	geom. percentage of web reinforcement
fyw	f_{yw}	[ksi → MPa]	yield strength of stirrups
fyw_rhow_100	$\frac{f_{yw} \cdot \rho_w}{100}$	[MPa]	smeared stirrup forces (stress)
fwtk	f_{wtk}	[ksi → MPa]	tensile strength of stirrups
fwtk/fyw	f_{wtk}/f_{yw}	[-]	ratio
ewuk	ε_{wuk}	[‰]	strain at tensile strength of stirrups

<u>Betondruckfestigkeit (concrete compressive strength)</u>

diaa	$\varnothing_a$	[in → mm]	max. diameter of aggregates
f1c	f_{1c}	[MPa]	uniaxial compr. strength of concrete
Method		[-]	test method (cyl; cu; pr)
fcwu	f_{cwu}	[MPa]	compr. strength of struts in web

<u>Betonzugfestigkeit (concrete tensile strength)</u>

f1cttest	$f_{1ct,test}$	[MPa]	test value for axial tensile strength
Method		[-]	test method (fl; sp)
betacttest	$\beta_{ct,test} = \frac{f_{1ct,test}}{f_{1c}}$	[-]	ratio
f1ctmcal	$f_{1ct,m,cal}$	[MPa]	calculated value of axial concrete tensile strength
betactcal	$\beta_{ct,cal} = \frac{f_{1ct,m,cal}}{f_{1c}}$	[-]	ratio

<u>mechanischer Bewehrungsgrad (mechanical reinforcement ratio)</u>

oms	$\omega_s = \frac{\rho_s \cdot f_{sy}}{f_{1c} \cdot 100}$	[-]	mechanical ratio of longitudinal reinforcement
oml	$\omega_l = \omega_s$	[-]	mechanical reinforcement ratio of tension chord
omwy	$\omega_{wy} = \frac{\rho_w}{100} \cdot \frac{f_{yw}}{f_{cwu}}$	[-]	mechanical reinforcement ratio of stirrups

<u>Versuch (test)</u>

g	$g = A_s \cdot 24$	[kip/in→kip/ft→kN/m]	calculated self weight
Vg	$V_g = g \cdot (0{,}5 \cdot c + (a - x_r))$	[kip → kN]	shear force due to self weight
F	F	[kip → kN]	ultimate load
Vu_F+g,Rep	$V_{u,F+g,Rep}$	[kip → kN]	reported shear force at failure with self weight
Vu_Rep	$V_{u,Rep}$	[kip → kN]	shear force at failure with self weight (from report)
Vu_gF	$V_{u,g+f}$	[kip → kN]	shear force at failure with calculated self weight
betar_meas	β_r	[°]	measured angle of inclined cracks
xr_meas	x_r	[-]	measured distance of crack from support axis
xr	x_r	[-]	distance of crack from support axis
sigswmeas	$\sigma_{sw,meas}$	[ksi → MPa]	measured stirrup stress at failure
sigswass	$\sigma_{sw,ass}$	[ksi → MPa]	assumed stirrup stress at failure
sigsw	σ_{sw}	[ksi → MPa]	stirrup stress at failure
omwu	$\omega_{wu} = \omega_{wy}(\sigma_{sw} / f_{yw})$	[-]	mechanical reinforcement ratio of stirrups at failure
br		[-]	type of failure
oft		[-]	other failure types
bem		[-]	remarks

Control criteria

konrect		[-]	rectangular cross-section

Bruchschnittgrößen (moment and shear force at failure)

Mu	$M_u = \frac{V_{u,Rep} \cdot a}{1000}$	[kNm]	max. moment at failure
muu	$\mu_u = \frac{M_u}{b \cdot d_s^2 \cdot f_{1c}}$	[-]	non-dimensional ultimate moment
vutest	$\upsilon_{u,\,test} = \frac{\tau_{u,\,test}}{f_{cwu}} = \frac{V_{u,\,Rep}}{b_w \cdot \zeta \cdot d \cdot f_{cwu}}$	[-]	non-dimensional shear force at failure

Innerer Hebelarm beim Bruch (inner lever arm at failure)

sigsl	$\sigma_{sl} = \frac{1-\sqrt{1-2 \cdot \mu_u / \kappa_c}}{\omega_l} \cdot \kappa_c \cdot f_{sy}$	[MPa]	stress in longitudinal reinforcement
xsitest	$\xi_{test} = \frac{\omega_l \cdot \sigma_{sl}}{\kappa_c \cdot f_{sy}}$	[-]	coefficient for depth of compr. zone
zetatest	$\zeta_{test} = 1 - \frac{\xi_{test}}{2}$	[-]	coefficient for inner lever arm
z_test	$z_{test} = \zeta_{test} \cdot d_s$	[mm]	inner lever arm

Kontrolle Biegung (check of flexural capacity)

epcu	$\varepsilon_{cu} = 4 - 2 \cdot \frac{f_{1,c}}{100}$	[‰]	maximum concrete strain
kapc	$\kappa_c = 1 - \frac{f_{1c}}{250}$	[-]	coefficient for maximum stress of stress block
zeta	ζ	[-]	coefficient for inner lever arm

z_	$z = d_s \cdot \zeta$	[mm]	inner lever arm
muflex	$\mu_{u,flex}$	[-]	dimensionsfree moment at flexural failure
Mu_flex	$M_{u,flex}$	[kNm]	moment at flexural failure
Vu_flex	$V_{u,flex}$	[kN]	shear force at flexural failure
betaflex	$\beta_{flex} = \frac{\mu_u}{\mu_{flex}}$	[-]	ratio

Querkraft – PT (für ν= 0,8) (ultimate shear force acc. to PT (for ν= 0,8))

sin2thp	$\sin^2\theta_p$	[-]	
thp	$\theta_p = \arcsin\sqrt{\left(\sin^2\theta_p\right)} \cdot \frac{180}{\pi}$	[°]	angle θ acc. to PT (measured against long axis)
cotthp		[-]	
vup	$\upsilon_{up} = \omega_{wy} \cdot \cot\theta_p$	[-]	ultimate non-dimensional shear force acc. to PT

Bruchquerkraft im Versuch (ultimate shear force at failure)

gamwp	$\gamma_{wp} = \frac{\upsilon_{u,test}}{\upsilon_{up}}$	[-]	model safety factor
cotthu	$\cot\theta_u = \frac{\upsilon_{u,test}}{\omega_{wu}}$	[-]	cotθ at failure
thu	$\theta_u = \arctan\left(\frac{1}{\cot\theta_u}\right) \cdot \frac{180}{\pi}$	[°]	cotθ at failure
nueu	$\nu_u = \frac{\left(0{,}8 \cdot \omega_{wu}\right)}{\sin^2\left(\theta_u \cdot \pi/180\right)}$	[-]	coefficient for effective strength ($\nu_u = f_{cwu}/f_{1c}$)

Verankerung (check of anchorage at end support)

betalb	$\beta_{lb} = \frac{l_{berf}}{l_{bvorh}}$	[-]	ratio

Druckfestigkeiten für Auswertungen (strength values for evaluations)

f1ck	$f_{1ck} = f_{1c} - 3{,}8$	[MPa]	characteristic uniaxial compressive strength
fcm_cyl	$f_{cm,cyl} = f_{1c} / 0{,}95$	[MPa]	mean cylinder strength
fck	$f_{ck} = f_{cm,cyl} - 4{,}0$	[MPa]	characteristic concrete cylinder strength
fc_prime	$f'_c = f_{ck} + 1{,}6$	[MPa]	characteristic cylinder strength of ACI 318