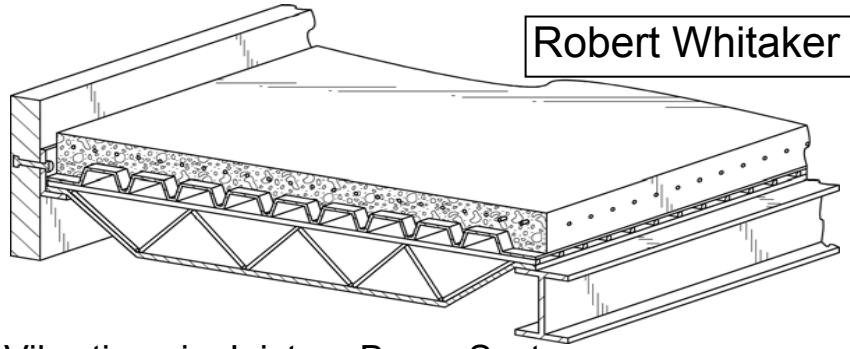
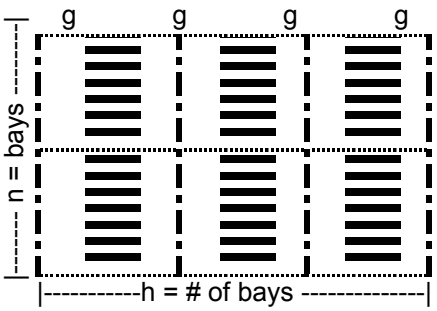


Robert Whitaker



Plan view

Design Loads	
DL	17.55 psf
LL	60 psf

Vibrations in Joist on Beam System

Based on AISC Steel design guide 11 ex 4.6 & 6.2

20K9	
w_{self} (plf)	10.8
$w_{total\ allow}$ (plf)	450.0
$w_{joist\ design}$ (plf)	233.1
d (in)	20.0
M_{allow} (ft-k)	49.51
A_{bottom} (in^2)	1.04
A_{top} (in^2)	1.30
A_{cord} (in^2)	2.35
I_{cord} (in^4)	209.0
I_{comp} (in^4)	466.2
y_c (in)	8.94

for spans of 30 feet

ok

W16x31	
w_{self} (plf)	31.0
A (in^2)	9.13
d (in)	15.70
Ix (in^4)	375.0

f_{allow} (k)	30 kip
ρ_{conc} (pcf)	145 pcf
Es (ksi)	29000 ksi
f'c (ksi)	3 ksi

Ec	3024 ksi
n	7.10

t_{conc}	3.00 in
t_{deck}	0.50 in
t_{tot}	3.50 in
teff =	3.25 in

*update Ws+d value

building	
n (# bays)	2 bays
h (# bays)	3 bays

LOADS		
Ws+d	39 psf	<== look up value in deck manual
DL	4.0 psf	<== 4 psf typ office service load
LL	11.0 psf	<== 11 psf typ office service load

Length	
Girder (Lg)	15 feet
Joist (Lj)	30 feet
Joist Spacir	2 feet

	joist	
L min =	24	144
Leff =>	24 in	

	girder	
L min =	72	360
Leff =>	72 in	

Joist	cord type:	angle
$\hat{y}_j$	0.556 in	
I_j	445 in^4	
Cr	0.884	
γ	0.132	
$I_f = I_{eff}$	348 in^4	Eq 3.16
I_{mod}	185 in^4	Eq 3.15
w_j	119 plf	
Δj	0.215 in	
f_j	7.63 hz	

6 < Lj/d= 18 < 24

therefore use Eq 3.16

Transformed Joist properties based on unit width

Ds	4.833 in^4/ft	Transformed moment of inertia per unit of width in x direction
Dj	173.76 in^4/ft	
Joist parallel to an interior edge?		flr width / Bj calc
Cj	2	no
Bj	20.00 ft	<2/3 * floor width
Wj	35.6 kips	

.==> Bj = 20 ft or 24.50 ft

Girder

$\hat{y}g$	4.29	in
Ig_{comp}	1472	in^4
$Ig_{non\text{-}comp}$	375	in^4
Ig_{red}	649	in^4
w_g	1813	plf
Δ g	0.110	in
fg	10.68	hz

Transformed Girder properties based on unit width

Dj	173.76	in^4/ft	Transformed moment of inertia per unit of width in x direction
Dg	21.64	in^4/ft	
Joist connected to girder web?			flr length Bg calc
Cg	1.6	no	.==> Bj = 60 ft or 40.40 ft
Bg	40.40	ft	<2/3 * floor length
Wg	36.6	kips	
Δ g'	0.082	in	Lg< Bj

Stiffness analysis (fn< 9 Hz, no need to check stiffness analysis)

using a 0.224 kip load

$\Delta_{j\ applied}$	0.02160	in	
$\Delta_{j\ pannel}$	0.00398	in	
$\Delta_{gPannel}$	0.00145	in	(fn= 6.21 Hz)
Δ_{total}	0.00471	in	fn ok
K_{floor}	47.6	kip/in	**>5.7kip/in limit ok**

Walking Evaluation

(fn= 6.21 Hz)

$W_{PANELtot}$	36.0	kips		
β	0.030	Res._mid low damp	table 4.1	
βW	1079.2	#		
P_o	65.0	#	table 4.1	compare with table 4.1
a_p/g =	0.00686	=	0.686% g fails > 0.5%	**fails**

Fails, need to increase joist size or slab thickness (delta j controls)

Midspan Flexibility

fn	6.21	hz				
de	3.25	in				
N_{eff} (# joists)	5.42	**>1.0 ok**	eq 4.7			use
0.018 ≤	de/Sj =	0.135	≤	0.208	**ok, use eq 4.7**	0.135417
4.5E+6 ≤	Lj^4/Ij =	48.3E+6	≤	257.0E+6	**ok, use eq 4.7**	48.3E+6
2 ≤	Lj/Sj =	15	≤	30	**ok, use eq 4.7**	15

Δ oj	96.4E-6	in/lb mid span flexibility
Δ_{gP}	3.2E-6	in/lb mid span flexibility
Δ p	19.4E-6	in/lb mid span flexibility

Table 4.1
Recommended Values of Parameters in Equation (4.1) and a_o/g Limits

	Constant Force P_o	Damping Ratio β	Acceleration Limit $a_o/g \times 100\%$
Offices, Residences, Churches	0.29 kN (65 lb)	0.02–0.05*	0.5%
Shopping Malls	0.29 kN (65 lb)	0.02	1.5%
Footbridges—Indoor	0.41 kN (92 lb)	0.01	1.5%
Footbridges—Outdoor	0.41 kN (92 lb)	0.01	5.0%

* 0.02 for floors with few non-structural components (ceilings, ducts, partitions, etc.) as can occur in open work areas and churches,
0.03 for floors with non-structural components and furnishings, but with only small demountable partitions, typical of many modular office areas,
0.05 for full height partitions between floors.

MODERATE WALK <------

W person	185	#			
step/min	75	step/min			
Fm/W	1.5	(table 6.2)	Uv=	5500 #	Hz^2
Fm	277.5	#			

SLOW WALK

W person	185	#			
step/min	50	step/min			
Fm/W	1.3	(table 6.2)	Uv=	1500 #	Hz^2
Fm	240.5	#			

f_o	2.5 hz	(figure 6.5)
f_n/f_o	2.483 >>0.5	use eq 6.4b
$T_o=1/f_o$	0.4 sec	
f_n*T_o	2.483 > 0.5	
Am	0.081	
X max	436 in x 10^-6	
V	**17,185 x 10^-6 in /sec**	compare with table 6.1 values

f_o	1.4 hz	(figure 6.5)
f_n/f_o	4.43 >>0.5	use eq 6.4b
$T_o=1/f_o$	0.7143 sec	
f_n*T_o	4.43 > 0.5	
Am	0.025	
X max	119 in x 10^-6	
V	**4,687 x 10^-6 in /sec**	compare with table 6.1 values

Table 6.1
Vibration Criteria for Sensitive Equipment

Facility Equipment or Use	Vibrational Velocity*	
	(μ in./sec)	(μm/sec)
Computer systems; Operating Rooms**; Surgery; Bench microscopes at up to 100x magnification;	8,000	200
Laboratory robots	4,000	100
Bench microscopes at up to 400x magnification; Optical and other precision balances; Coordinate measuring machines; Metrology laboratories; Optical comparators; Microelectronics manufacturing equipment—Class A***	2,000	50
Micro surgery, eye surgery, neuro surgery; Bench microscopes at magnification greater than 400x; Optical equipment on isolation tables; Microelectronics manufacturing equipment—Class B***	1,000	25
Electron microscopes at up to 30,000x magnification; Microtomes; Magnetic resonance imagers; Microelectronics manufacturing equipment—Class C***	500	12
Electron microscopes at greater than 30,000x magnification; Mass spectrometers; Cell implant equipment; Microelectronids manufacturing equipment—Class D***	250	6
Microelectronics Manufacturing equipment—Class E***; Unisolated laser and optical research systems	130	3

* Value of V for Figure 6.1.
** Criterion given by solid curve of Figure 6.1 corresponds to a standard mean whole-body threshold of perception (Guide 1974)
*** Class A: Inspection, probe test, and other manufacturing support equipment.
Class B: Aligners, steppers, and other critical equipment for photolithography with line widths of 3 microns or more.
Class C: Aligners, steppers, and other critical equipment for photolithography with line widths of 1 micron.
Class D: Aligners, steppers, and other critical equipment for photolithography with line widths of ½ micron; includes electron-beam systems.
Class E: Aligners, steppers, and other critical equipment for photolithography with line widths of ¼ micron; includes electron-beam systems.

a/g==>V= 71544.96