ARCHITECTURAL STRUCTURES:
FORM, BEHAVIOR, AND DESIGN

ARCH 331

DR. ANNE NICHOLS

SUMMER 2014

lecture
sixteen

Paris 2002/09,
Eiffel Tower

steel construction:
trusses, decks & plate girders

Iron & Steel Trusses

- *cast iron*
  - *18th century*
  - *chain links*
- *wrought-iron*
- *rivets*
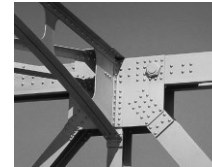
http:// nisee.berkeley.edu/godden

Truss Connections

- **gusset plates**
- **bolts**
- **welds**

http://courses.civil.ualberta.ca
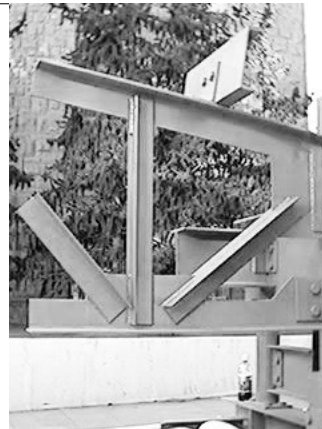
(AISC - Steel Structures of the Everyday)

Trusses

http:// nisee.berkeley.edu/godden

- *require lateral bracing*
- *consider buckling*
- *indeterminate trusses*
  - *extra members*
    - *diagonal tension counters*
  - *solvable with statics*
    - *cables can't hold compression*
  - *displacement methods*
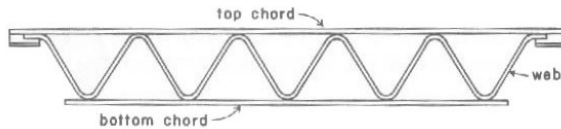   - *elastic elongation*
  - *too few members, unstable*

One Mantime Plaza, SOM 1964

1
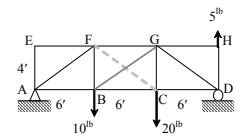
Manufactured Trusses

- *open web joists*
- *parallel chord*

top chord

web

bottom chord

(c) SECTION THRU JOISTS SHOWING FLANGE TYPES

Open Web Joists

- *SJI: www.steeljoist.com*
- *Vulcraft: www.vulcraft.com*
  - *K Series (Standard)*
    - *8-30" deep, spans 8-50 ft*
  - *LH Series (Long span)*
    - *18-48" deep, spans 25-96 ft*
  - *DLH (Deep Long Spans)*
    - *52-72" deep, spans 89-144 ft*
  - *SLH (Long spans with high strength steel)*
    - *pitched top chord*
    - *80-120" deep, spans 111-240 ft*

SPAN

[DESIGN LENGTH = SPAN − 0.33 FT.]

Parallel chord joists installed to a slope greater than ½ inch per foot shall use span defined by the length along the slope.

MIN 1/4 | 12
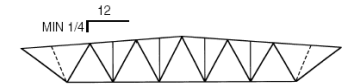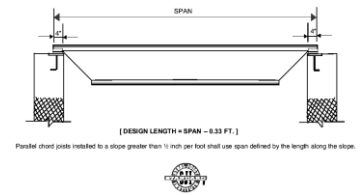
Load Tables - w

LRFD

STANDARD LOAD TABLE FOR OPEN WEB STEEL JOISTS, K-SERIES
Based On A 50 ksi Maximum Yield Strength - Loads Shown In Pounds Per Linear Foot (plf)

Joist Designation	10K1	12K1	12K3	12K5	14K1	14K3	14K4	14K6	16K2	16K3	16K4	16K5	16K6	16K7	16K9
Depth (in.)	10	12	12	12	14	14	14	14	16	16	16	16	16	16	16
Approx. Wt (lbs./ft.)	5.0	5.0	5.7	7.1	5.2	6.0	6.7	7.7	5.5	6.3	7.0	7.5	8.1	8.6	10.0
Span (ft.)															
10	825 / 550														
11	825 / 542														
12	825 / 455	825 / 550	825 / 550	825 / 550											
13	718 / 363	825 / 510	825 / 510	825 / 510											
14	618 / 289	825 / 425	825 / 463	825 / 463	825 / 550	825 / 550	550	550							
15	537 / 234	651 / 344	814 / 428	825 / 434	766 / 475	825 / 507	825 / 507	825 / 507							
16	469 / 192	570 / 282	714 / 351	825 / 396	672 / 390	825 / 467	825 / 467	825 / 467	825 / 550	825 / 550	825 / 550	825 / 550	825 / 550	825 / 550	825 / 550
17	415 / 159	504 / 234	630 / 291	825 / 366	592 / 324	742 / 404	825 / 443	768 / 488	825 / 526	825 / 526	825 / 526	825 / 526	825 / 526	825 / 526	825 / 526
18	369 / 134	448 / 197	561 / 245	760 / 317	528 / 272	661 / 339	795 / 397	825 / 409	684 / 456	762 / 490	825 / 490	825 / 490	825 / 490	825 / 490	825 / 490
19	331 / 113	402 / 167	502 / 207	681 / 269	472 / 230	592 / 287	712 / 336	825 / 383	612 / 386	682 / 452	820 / 455	825 / 455	825 / 455	825 / 455	825 / 455
20	298 / 97	361 / 142	453 / 177	613 / 230	426 / 197	534 / 246	642 / 287	787 / 347	552 / 297	615 / 330	739 / 386	825 / 426	825 / 426	825 / 426	825 / 426
21		327 / 123	409 / 153	555 / 198	385 / 170	483 / 212	582 / 248	712 / 299	499 / 255	556 / 285	670 / 333	754 / 373	822 / 405	825 / 406	825 / 406
22		298 / 106	373 / 132	505 / 172	351 / 147	439 / 184	529 / 215	648 / 259	454 / 222	505 / 247	609 / 289	687 / 323	747 / 351	825 / 385	825 / 385
23		271 / 93	340 / 116	462 / 150	321 / 128	402 / 160	483 / 188	592 / 226	415 / 194	462 / 216	556 / 252	627 / 282	682 / 307	760 / 339	825 / 363

load for live load deflection limit (L/360) in RED
total in BLACK

Decks

- *sheet steel*
- *composite*
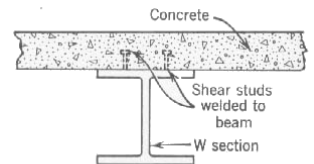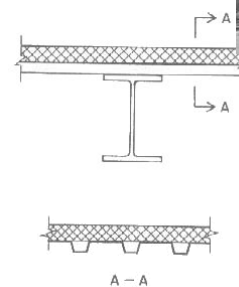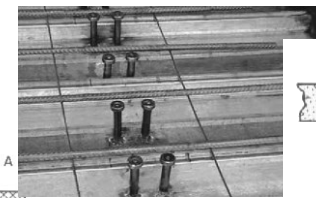
Concrete

Shear studs welded to beam

W section

(c) Composite beam.

A

A

A − A

B

B

B − B

(b)
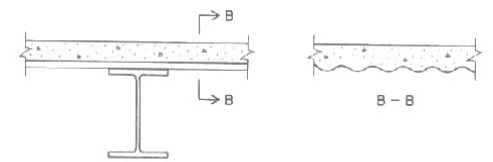
Light-gage Steel

- sheet metal

  - shaped
  - studs, panels, window frames
  - gage
    - based on weight of 41.82 lb/ft^2 / inch of thickness
    - 24, 22, 18, 16, i.e.
    - 0.0239, 0.0329, 0.0474, 0.0598 in
    - 0.6, 0.85, 1.0, 1.3, 1.6 mm

Steel Trusses 9
Lecture 19
Foundations Structures
ARCH 331
F2008abn
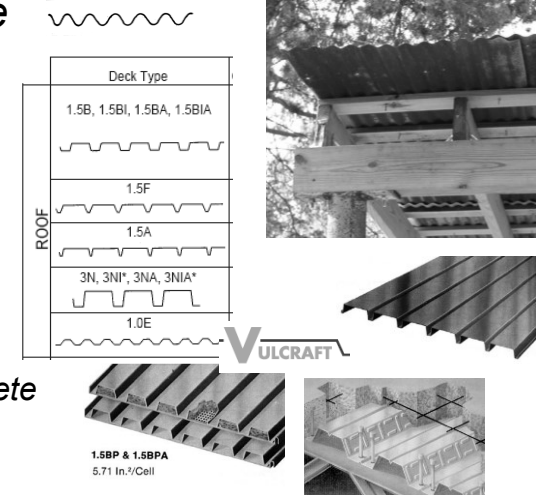
Steel Decks

- "Texas" style
  - corrugated
- common

  - 1 – 3 spans
  - can be insulated
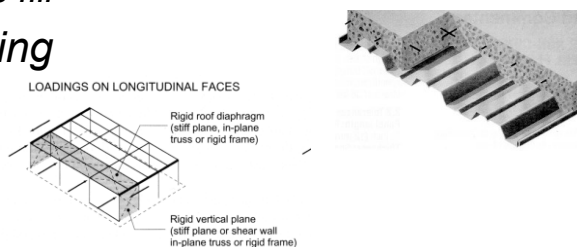 - composite
    - with concrete

Steel Trusses 10
Lecture 19
Foundations Structures
ARCH 331
F2008abn

Steel Decks

- common fire proofing
  - cementitious spray
  - composite concrete
- non-composite
  - concrete is fill
- lateral bracing
- diaphragm action

LOADINGS ON LONGITUDINAL FACES

Rigid roof diaphragm
(stiff plane, in-plane truss or rigid frame)

Rigid vertical plane
(stiff plane or shear wall
in-plane truss or rigid frame)
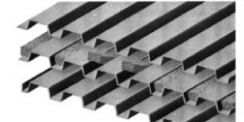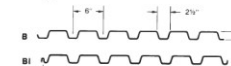
Steel Trusses 11
Lecture 16
Foundations Structures
ARCH 331
Su2011abn

Load Tables - w

- live load deflection limit L/240

1.5 B, BI, BA, BIA
Maximum Sheet Length 42'-0 — ICBO Approved (No.3415)
Factory Mutual Approved
Deck type & gauge — Max. deck span
1.5B22, 1.5BI22..................6'-0
1.5B20, 1.5BI20..................6'-6
1.5B18, 1.5BI18..................7'-5
FM Approvals No. 0C8A7.AM & 0G1A4.AM**

VERTICAL LOADS FOR TYPE 1.5B

No. of Spans	Deck Type	Max. SDI Const. Span	Allowable Total (Dead + Live) Uniform Load (PSF) Span (ft.-in.) C. to C. of Support									
			5'-0	5'-6	6'-0	6'-6	7'-0	7'-6	8'-0	8'-6	9'-0	9'-6	10'-0
1	B 24	4'-8	66	52	42	36	30	27	24	21	20		
	B 22	5'-7	91	71	57	47	40	34	30	27	24	22	20
	B 21	6'-0	104	81	64	53	44	38	33	29	26	24	22
	B 20	6'-5	115	89	71	58	48	41	36	31	28	25	23
	B 19	7'-1	139	107	85	69	57	48	41	36	32	29	26
	B 18	7'-8	162	124	98	79	65	55	47	41	36	32	29
	B 16	8'-8	206	157	123	99	81	68	58	50	44	39	34
2	B 24	5'-10	126	104	87	74	64	55	47	41	36	32	29
	B 22	6'-11	102	85	71	61	52	46	40	35	32	28	26
	B 21	7'-4	118	97	82	70	60	52	46	41	36	33	29
	B 20	7'-9	132	109	91	78	67	59	51	46	41	36	33
	B 19	8'-5	154	127	107	91	79	69	60	53	48	43	39
	B 18	9'-1	174	144	121	103	89	78	68	60	54	48	44
	B 16	10'-3	219	181	152	130	112	97	86	76	68	61	55
	B 24	5'-10	130	100	79	65	54	45	39	34	31	27	25
	B 22	6'-11	128	106	89	76	65	57	50	44	39	34	31
	B 21	7'-4	147	122	102	87	75	65	56	49	42	38	34

Steel Trusses 12
Lecture 19
Foundations Structures
ARCH 331
F2008abn

Plate Girders

- welds
- web stiffeners

http:// nisee.berkeley.edu/godden

stiffeners at end where shear is greatest and at support

plate web

angle stiffeners

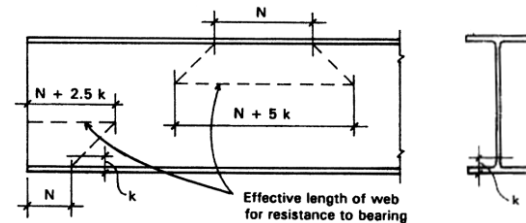thicker flange in center where moment is greatest

PLATE GIRDER   BOX GIRDER
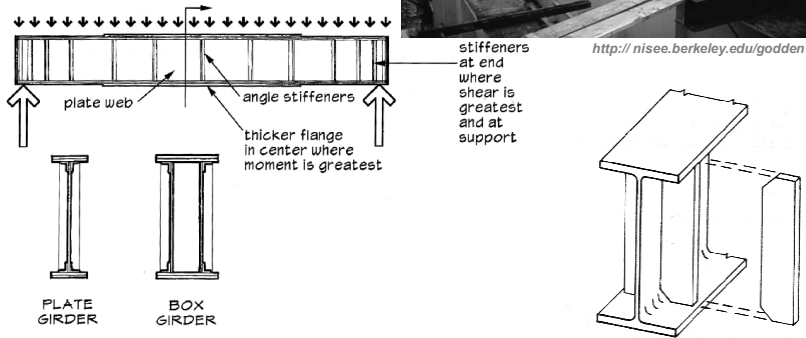
stiffeners to prevent lateral buckling

Web Bearing

- max loads

$$P_{n(max-end)} = (N + 2.5k)F_y t_w$$
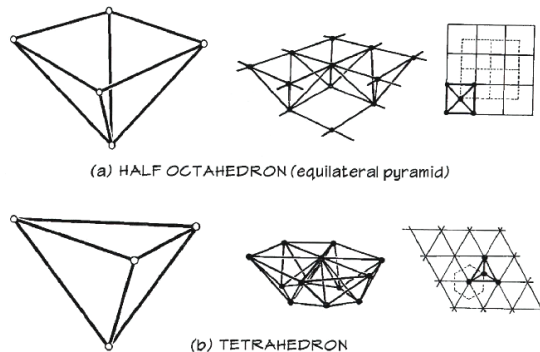
$$P_{n(max-interior)} = (N + 5k)F_{yw} t_w$$

N

N + 2.5 k

N + 5 k

N   k

Effective length of web for resistance to bearing

k

Space Trusses

- 3D with 2 force bodies and pins
  - pyramid
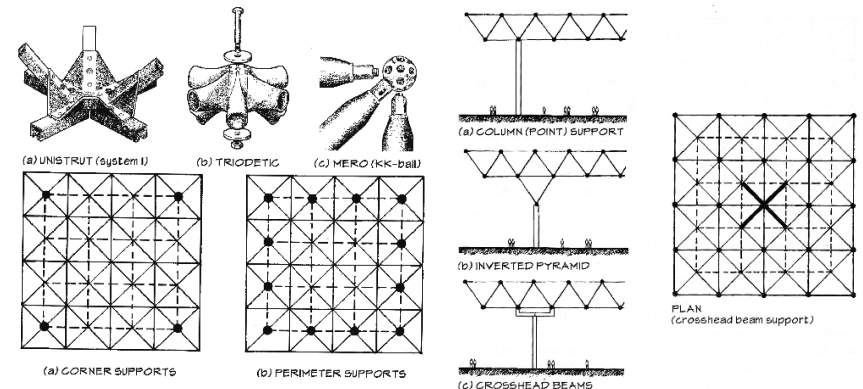 - tetrahedron
- "frames" have fixed joints
- layers
- 40's

(a) HALF OCTAHEDRON (equilateral pyramid)

(b) TETRAHEDRON

Space Trusses

- connections
- supports

(a) UNISTRUT (system I)   (b) TRIODETIC   (c) MERO (KK-ball)

(a) COLUMN (POINT) SUPPORT

(b) INVERTED PYRAMID

(c) CROSSHEAD BEAMS

(a) CORNER SUPPORTS   (b) PERIMETER SUPPORTS

PLAN (crosshead beam support)

Space Trusses

http://nisee.berkeley.edu/godden

Space Trusses

http://nisee.berkeley.edu/godden

Tensegrities

- *3D frame*
- *discontinuous struts*
- *continuous cables*
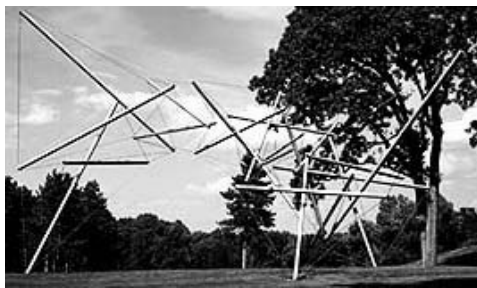
Free Ride Home – Kenneth Snelson

Method of Sections

- *relies on internal forces being in equilibrium on a section*
- *cut to expose <u>3 or less</u> members*
- *coplanar forces* $\rightarrow \sum M = 0$ *too*
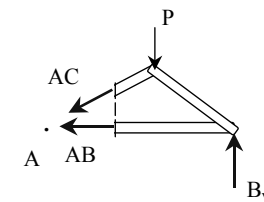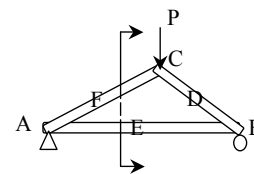
Method of Sections

- *joints on or off the section are good to sum moments*

- *quick for few members*

- *not always obvious where to cut or sum*