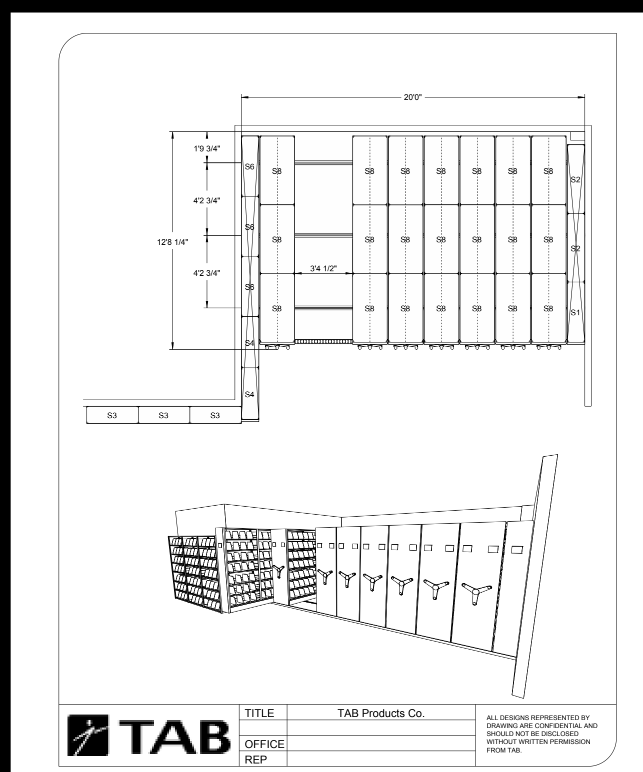
FLOOR LOAD HANDBOOK



COMPACT MOBILE FILE SYSTEM (CMFS)

Professional Services • Filing Systems • Technology Solutions • Storage Systems

Introduction

A compact mobile file system (CMFS) consists of shelving (and/or cabinets) mounted on moveable carriages that roll on fixed tracks so that only one aisle space is required for several rows of shelving. Compact mobile file systems are used to store paper media of all varieties, (records, files, documents, books, maps, xray films, motion picture films, artifacts, etc.) Compact mobile file systems significantly increase the available storage capacity when compared to static file systems. Consequently, floor loading may increase beyond the normal floor design live load.

This handbook is written for the professional licensed architects and engineers who will review the floor system and determine its ability to safely support the CMFS. TAB Products Co. **will not determine** if a high density mobile storage system can be installed on a particular floor since this is the responsibility of the architect and structural engineers of record. TAB has provided example calculations, diagrams, and useful charts. TAB will also provide suggestions and alternatives in order to successfully resolve a floor loading problem if one exists.

When considering placing a CMFS on a structural floor (composed of slabs, beams, and girders) the architect or engineer of record should consider the entire structural floor assembly. Most CMFS are relatively small and can be installed on structural floors without retrofitting the existing structure. For existing buildings, additional structural support, if required, will be more economical if the support beams are installed above the slab. For buildings being designed or being built, the addition of beams under the tracks and beams and girder reinforcement, if required, should occur below the floor.

The structural floor system has to be reviewed for both stress and deflection. A CMFS is very sensitive to floor deflection. The ball bearing housed wheels will move by gravity if the floor deflects significantly after the system is loaded. This carriage movement is called "drifting." Therefore, to help eliminate drifting, it is important for the design professional to use realistic loads in order to determine floor deflection. This guideline will address the various aspects of the design so that the design professional can successfully place a CMFS on a structural slab.

Floor Loads

The entire weight of the CMFS is supported by continuous tracks which in turn are supported by the structure. These track "line loads" can be large – see the Track Loading Chart on page 6. The use of average load per square foot or an equivalent "uniform" load may yield erroneous results. Nominal beams or plates above the floor can be used to support the track forces to the supporting floor beams for existing buildings. Some concrete framed slabs may not need any additional supports (concrete flat slabs, flat plates, waffle slabs, etc.) For design purposes, **no** live load occurs between the CMFS tracks. When considering an "open aisle" within the CMFS, a realistic live load for this aisle is to place a 200 pound person in front of each shelving cabinet, i.e. 200 lbs/3ft. of carriage length.

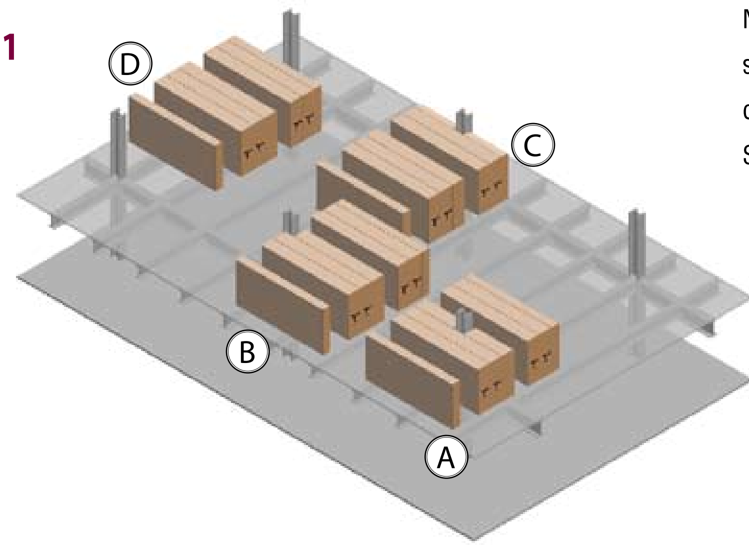
Equivalent open aisle live load is $\triangleq$ 200lbs ÷ 3ft. x 3ft. = 22lbs/sq. ft.

As previously stated, the use of an equivalent uniform live load is not appropriate for a CMFS due to the large track forces. Slabs and individual beams can easily be overstressed or deflect so that mobile file carriages can drift. An equivalent uniform live loading may be appropriate when a CMFS is located on a concrete flat slab or flat plate or other heavily designed concrete floor systems. Since a CMFS is a "real load," shear stresses and floor deflection for concrete flat plates should be reviewed.

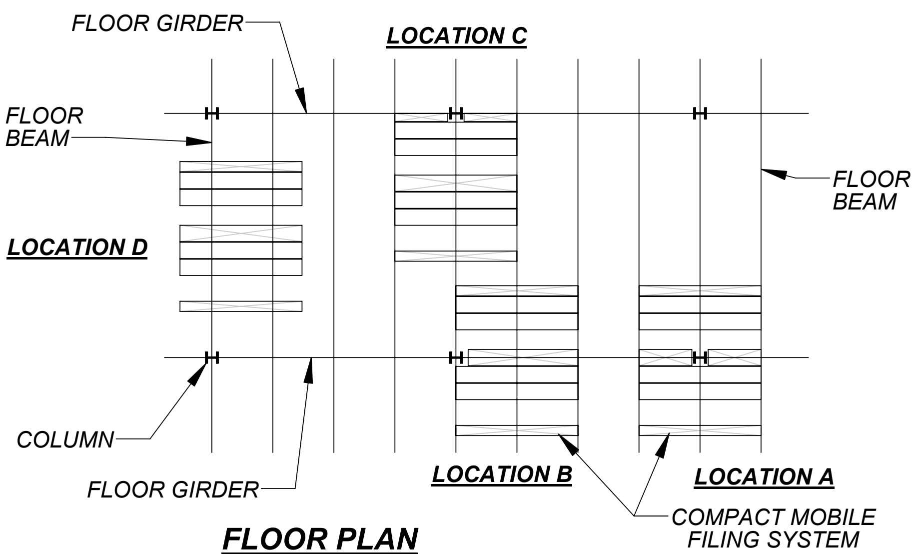
Location

The optimum location for a CMFS is to be located over or adjacent to a girder or beams adjacent to a column. See Figure 1 and Floor Plan. Location A is optimum, spreading the loads on 2 girders and at the ends of the floor beams. Location B, the next most favorable position, puts all the load on one girder and at the ends of the floor beams. Location C puts all the load near the ends of the floor beams. At location D, the CMFS will induce maximum bending stress and deflection of the floor beams. Location D should be avoided if possible.

Figure 1



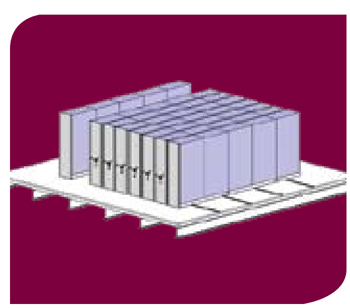
Note: For all of the examples shown in Figure 1, the file orientation can be rotated 90˚. See Track Orientation below.



FLOOR PLAN

Track Orientation

The ideal track orientation is perpendicular to the floor beams (or joists) or, where the floor beams are spaced 6 ft. or less, then directly over the floor beams. If the tracks are parallel to the floor beams, secondary framing may be required if the floor slab is structurally inadequate to support the track line loads. TAB Products Co. can space the tracks at any spacing requirement up to a maximum of 7 ft – 2¾ in. If at all possible, locate a track directly over a girder or floor beam. This may eliminate a track support beam.



Most CMFS systems can be rotated 90˚, especially if the system is within an open landscaped office area. The rotated system may have a completely new configuration (number of carriages and/or carriage length). One of the main reasons for rotating a system is to place the tracks perpendicular to the floor beams and eliminate secondary beams to support the track beams. This will lower the CMFS decking height above the floor and reduce the ramp length. See Figure Two.

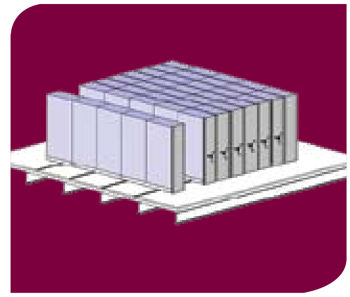
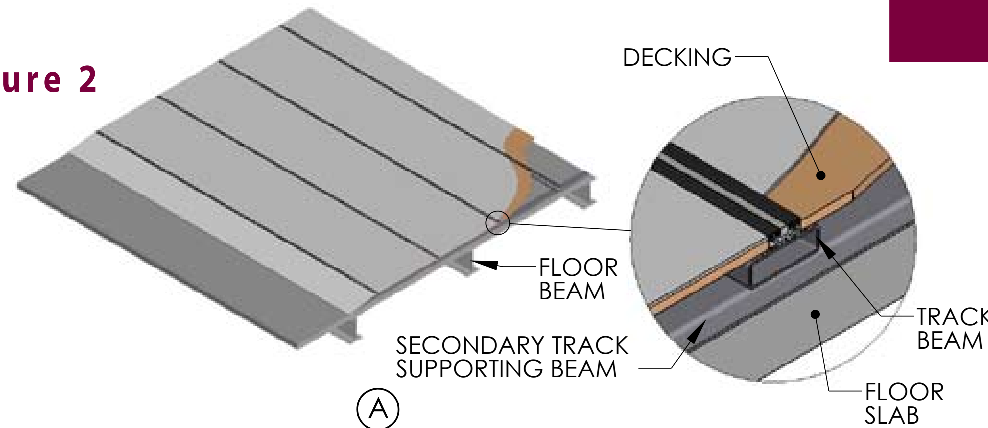
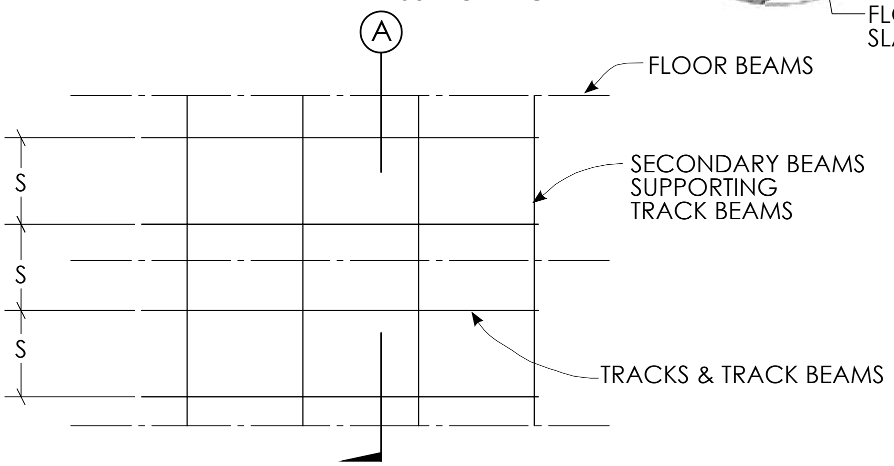
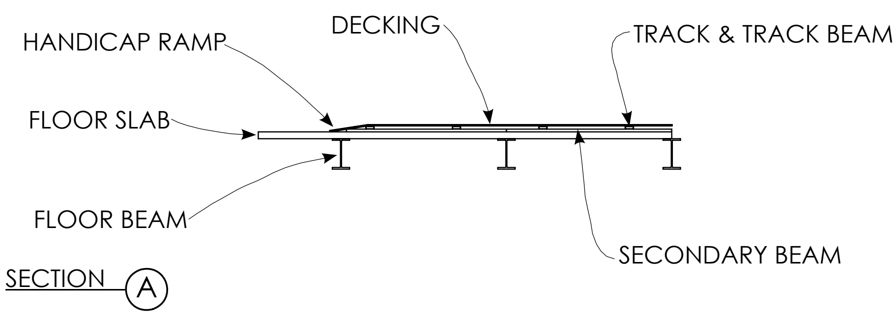


Figure 2





Floor Plan - tracks parallel and offset from floor beams



Placing track support beams in the same depth as the track beams will be difficult due to building access. All material has to be put into standard elevators and taken through corridors and doorways. Welding on site should be avoided if possible. All connections should be bolted.

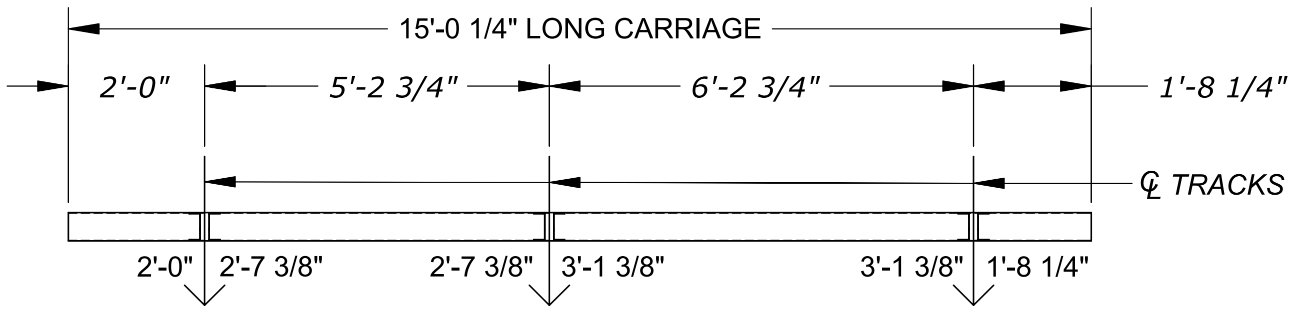
Handicap Access

ADA requires that all office functions have to be accessible to the handicapped. This ruling required the construction of the handicap ramps (maximum slope of 1:12). Long handicap ramps typically are difficult to install due to the amount of space they use. The handicap ramp may reduce the size of a system or require a system to be rotated in order to keep the ramp as short as possible. Some solutions may require elevating the entire floor within the file room and having a ramp at the room entry.

Track Loads

TAB Products Co. uses four standard track spacing; 4 ft. – 2¾ in., 5 ft. - 2¾ in., 6 ft. - 2¾ in., and 7 ft. - 2¾ in. Custom spacing is available at a small increase in cost. The track load can be obtained using tributary carriage length for each track. See Figure 3. Compute tributary carriage length and then calculate the track load from the Track Loading Chart. The maximum wheel load may be calculated in a similar manner.

Figure 3



Tributary Carriage Length (example)

After the track line loads are calculated from the Track Loading Chart, the floor slab can be reviewed for strength and deflection. If the slab does not have adequate capacity, a track reinforcement beam can be installed beneath the track to span to the floor beam or to the secondary track support beams.

TAB Products Co. has provided a design chart showing the track loads (lbs/lineal ft.) as well as wheel loads for various types of shelving systems and number of file levels. Letter and Legal paper media use the industry standard recommended weights of 2 lbs/lineal inch for letter size media and 2.5 lbs./lineal inch for legal size media. X-ray film is 8.33 lbs./lineal inch (100 lbs./lineal ft.). See Track Loading Chart. Other media weight can be used by modifying the LIVE LOAD column, adjusting the TOTAL LOAD column and, by ratio, arriving at the track load.

Criteria:

1. Carriage is assumed to weigh 47 lbs./lineal foot.
2. Track and Grout are assumed to weigh 4 lbs./lineal foot of track. Average track and grout weight is 2 lbs./lineal foot of carriage.
3. Decking weight is assumed to be 8 lbs./lineal foot of carriage (based on legal carriage width and 3 lbs./sq. ft. for deck and finished flooring.
4. Total carriage, track and deck weight is 57 lbs./lineal foot. This will be approximately 2 lbs./lineal foot greater than the actual weight for letter size systems and approximately 2 lbs./lineal foot under the actual weight for x-ray size systems.
5. The tabulated live load assumes full utilization of the shelving system without reduction for post widths.
6. Shelving weight is the tabulated shipping weight and is approximately 5% larger than actual in-use weight.
7. Weight of finished end panels is not included. Front track load can be estimated based on tributary carriage width plus end panel weight. Front track total load may be critical for carriages with track spacing 4'-2 3/4" or less.
8. Pull-out work shelf weight is not included in the tabulated dead load column. Add weight of work shelves where required.
9. A 1" bumper space is assumed between shelving. Carriages are a 1/4" wider than the shelving and 3/4" bumpers are between carriages. Actual carriage spacing is the carriage width plus 3/4" for the bumper.
10. Tabulated track load is the full weight of carriage, shelving, decking, track, and media divided by the actual carriage spacing.
11. Actual design track load can be calculated by using the ratio of the tributary track width divided by the standard track spacing times the track load (or wheel load).

Track Loads (Cont.)

Track Loading Chart													
MEDIA	UNIT LIVE LOAD	No. FILING LEVELS	SHELVING TYPE	CARRIAGE WIDTH	DEAD LOAD	LIVE LOAD	TOTAL LOAD	TRACK LOAD LBS./FT. TRACK SPACING			WHEEL LOAD LBS. TRACK SPACING		
	LBS./ IN.				LBS./FT.	LBS./FT.	LBS./FT.	4'-2 3/4"	5'-2 3/4"	6'-2 3/4"	4'-2 3/4"	5'-2 3/4"	6'-2 3/4"
SMALL BOOKS 9" WIDE SHELVES	1.75	6	CANTILEVER LIBRARY SHELVING	21"	101	252	353	814	1007	1200	746	923	1099
		7			106	294	400	923	1141	1359	846	1046	1246
LARGE BOOKS 12" WIDE SHELVES	3.0	6		25"	114	432	546	1066	1318	1569	1155	1428	1701
		7			121	504	625	1220	1508	1797	1322	1634	1947
LETTER PAPER SIZE DOCUMENTS	2.0	6	4 POST "L" & "T" SHELVING	24.25"	115	288	403	810	1002	1193	852	1054	1255
		7			125	336	461	927	1146	1365	975	1205	1436
		8			133	384	517	1039	1285	1531	1093	1352	1610
		6	USF FLAT SHELVES	29.25"	145	288	433	720	891	1061	916	1132	1349
		7			155	336	491	817	1010	1203	1038	1284	1529
LEGAL PAPER SIZE DOCUMENTS	2.5	6	4 POST "L" & "T" SHELVING	30.25"	134	360	494	802	992	1182	1045	1292	1539
		7			143	420	563	914	1131	1347	1190	1472	1753
		8			154	480	634	1030	1273	1517	1341	1658	1975
		6	USF FLAT SHELVES	35.5"	159	360	519	722	892	1063	1097	1357	1616
		7			171	420	591	822	1016	1210	1250	1545	1841
USF SHELVING WITH PLASTIC UNIT BOXES	2.0	6	LETTER USF	29.25"	132	275	407	677	837	997	861	1064	1268
		7			142	322	464	772	955	1137	981	1213	1445
	2.5	6	LEGAL USF	35.5"	135	345	480	667	825	983	1015	1255	1495
		7			145	403	548	762	942	1122	1159	1433	1707
X-RAY FILM	8.33	5	4 POST	36.25"	185	1000	1185	----	----	----	2506	3098	3691

The chart above covers typical filing applications. For assistance call TAB Customer Service at 1-800-827-3288.

Track Reinforcement

TAB Products Co. has also provided a Track Reinforcement Design Chart. Critical reinforcement beam stress and deflection conditions occur based upon maximum wheels loads for the floor beams (joists) spaced less than 8"-0. In order to reduce size and/or height of the reinforcing beam under the tracks, reduce the track spacing as required. From an installation and cost standpoint, tracks should not be closer together than 3 ft. – 0in. o.c.

Track Reinforcement Design Chart									8'-0" Max. Support Span		
Member size	Weight	Section Properties			Max. Wheel Load for All Carriage Widths				Max. Equivalent Load / LIN. FT.		Max. Wheel Load
W x H x t	LBS./ FT.	t IN.	S IN.^{3}	I IN.^{4}	Max. Support Spacing				Carriage Width		
					24"	30"	36"	48"	21",24.25",25"	29.5" & 30.25"	35.5" & 36.25"
TS 6 x 2 x 3/16	9.4	0.174	1.80	1.80	1500 LBS.	1500 LBS.	1450 LBS.	1200 LBS.			
TS 6 x 2 x 1/4	12.2	0.233	2.21	2.21	2800 LBS.	2500 LBS.	2400 LBS.	1850 LBS.			
TS 6 x 2 x 5/16	14.8	0.291	2.52	2.52	4000 LBS.	3700 LBS.	3400 LBS.	2400 LBS.			
TS 6 x 2 x 3/8	17.3	0.349	2.75	2.75			4000 LBS.	2800 LBS.			
TS 8 x 2 x 3/8	22.4	0.349	3.72	3.72				3150 LBS.			
TS 6 x 3 x 5/16	17.0	0.291	4.44	6.66				3350 LBS.			
TS 6 x 3 x 3/8	19.8	0.349	4.98	7.47				4000 LBS.			
TS 6 x 4 x 3/16	12.0	0.174	4.38	8.76					1150 LBS./FT.	1075 LBS./FT.	1450 LBS.
TS 6 x 4 x 1/4	15.6	0.233	5.56	11.10					1450 LBS./FT.	1450 LBS./FT.	2000 LBS.
TS 6 x 4 x 5/16	19.1	0.291	6.57	13.10					1650 LBS./FT.	1600 LBS./FT.	2500 LBS.
TS 8 x 4 x 1/4	19.0	0.233	7.21	14.40					1750 LBS./FT.	---	---
TS 8 x 4 x 5/16	23.3	0.291	8.58	17.20					2250 LBS./FT.	---	3000 LBS.
TS 8 x 4 x 3/8	27.5	0.349	9.79	19.60					---	---	3750 LBS.

Floor Beam & Girder Analysis

A typical office floor environment seldom weighs what was used in the original design live load calculations. Common practice is to evaluate the beams and girders in the entire bay (bays) that the CMFS occupies. By using realistic floor loads, the actual beam stress and deflections may be computed. The actual partition load should be used as well as furniture and occupant load. An example might be a 10’ x 12’ office adjacent to the file area. The ceiling height is 9 ft. Average partition load, assuming metal studs at 24 in. o.c. and 5/8” gypsum board, is 9 ft. (2 x 2.8 lbs/sq. ft. (gypsum board) plus .4 lbs. (stud and tracks)) = 54 lbs./lineal ft. Partition load = 54lbs divided by 12 ft. plus 54lbs. divided by 10ft. $\hat{=}$ 10.0 lbs/sq. ft. which is half of the typical partition design load of 20 lbs./sq. ft. The average office, furnished with a desk, credenza, file, etc. may not be able to accommodate more than two or three people. The typical design live load of 50 lbs/sq. ft. in a 10 ft. x 12 ft. office allows for 6000 lbs. for furniture and occupants. Obviously, the “real” load will be a lot less than the 6000lb. design load. By reducing the live load to a realistic level, most beams will have adequate capacity to safely support a small and moderate size CFMS.

The beams will also have to be checked for deflection. The Track Loading Chart assumes full utilization of the shelving capacity. This is a maximum weight assuming there is **no** empty file space in the shelving. Most offices have their file shelves filled from 70% to 90% of maximum capacity to allow for future growth and for ease of insertion and retrieval of files. Reducing the live load portion of the file system by 10% is prudent when calculating beam and girder deflection. It’s realistic for beams and girders to be checked only for the weight of the file system and 90% of the file media. This will approximate the deflection the CMFS will experience after the media has been installed. The weight of existing partitions, furniture, other furnishings, etc. are already on the floor and have deflected the beams prior to installation of the tracks. The tracks are set level and grouted. Track deflection (floor deflection) occurs after the installation of the carriages, shelving, and media.

Floor Deflection

Floor deflection always occurs after the file system has been loaded. The responsibility of the design professionals is to keep the floor deflection to a minimum amount to prevent the carriages from drifting. Carriages tend to drift if the floor slopes more than 3/16 in. in 8 ft. of track length. Some structures have long span beams and girders and will be too flexible to prevent carriage drifting. See also, the **New Structure Design Criteria Supporting the CMFS** section.

There are a few solutions to preventing carriage drifting. They are:

1. **Wheel “brakes”.** Adjustable friction “brakes” can be installed on the wheels to prevent drifting. The “brakes” will make a mechanical assist system harder to operate since the operator will have to overcome the friction “brake” as well as move the carriage. A larger gear ratio drive can help overcome this problem.

2. **Electric drive system.** An electric drive system has an automatic braking system and will prevent drifting. The electric drive systems are generally used for large file systems but can be installed in smaller systems. This solution may be cost effective when compared to retrofitting the structure.

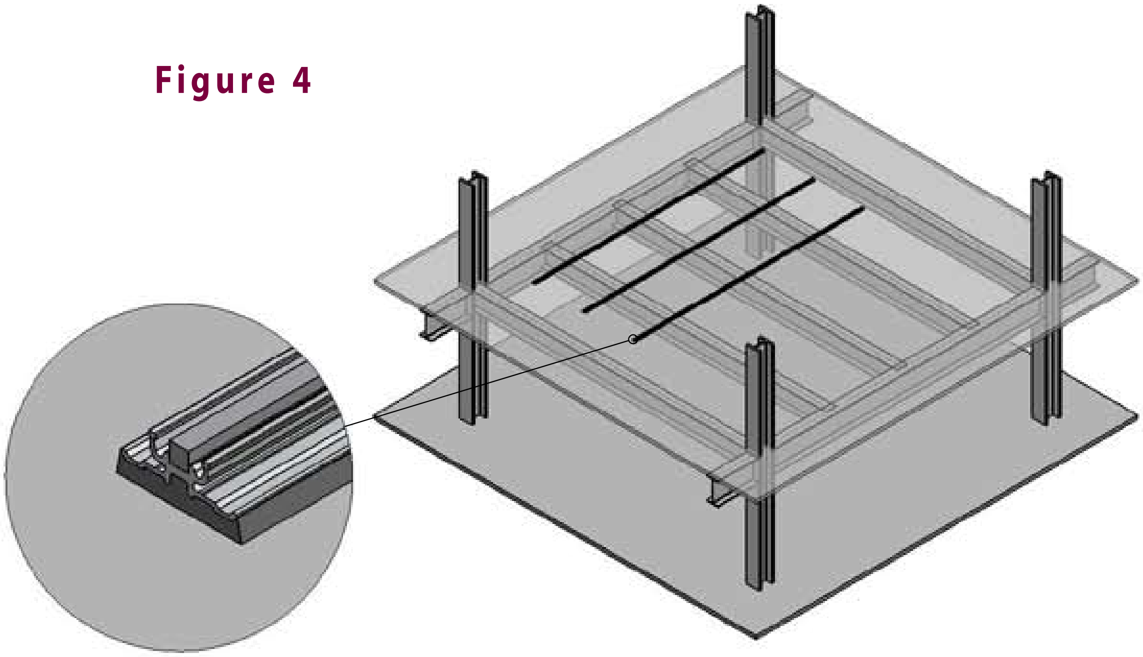
3. **Stepping and/or cambering the floor tracks.** Some floor framing systems have a consistent pattern of beams, i.e., all beams are the same size, same length, and at the same spacing. When floor deflection can be reasonably predicted, the tracks can be raised to compensate for the future anticipated floor deflection. See Figures 4 and 5. Elevating the tracks has to be done carefully. The carriages have to operate with and without media. Carriage brakes should be installed without friction and then adjusted after the shelving and media are installed in the event that drifting still occurs.

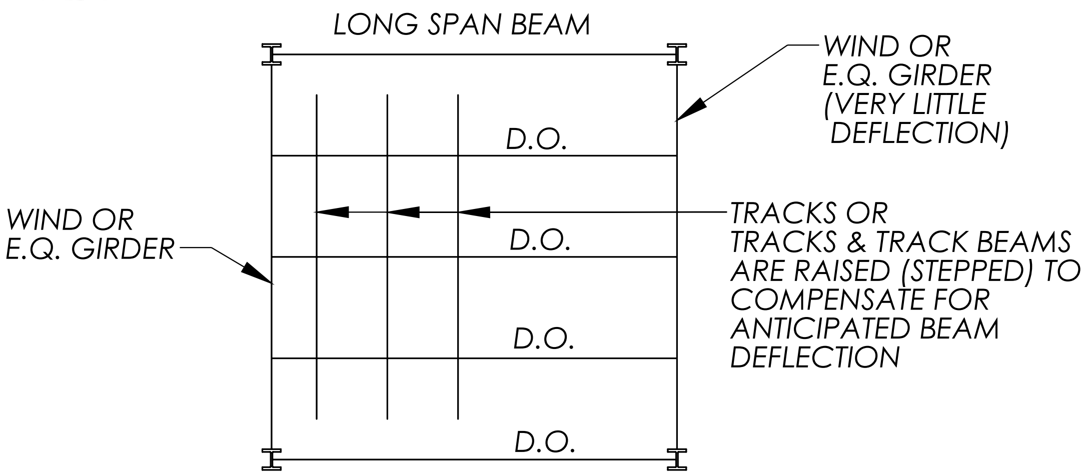
   Track stepping and track cambering will always be approximate. It is best to step or camber tracks in a uniform manner so that the carriage will move properly. If the resulting track slopes and causes drifting, wheel brakes can be installed.

   After the shelving is loaded the carriage will have 1/16” camber at the center track. The carriage can accomodate this amount of camber.

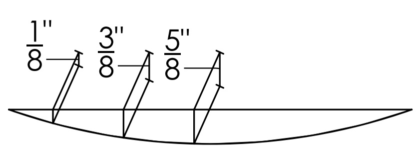
Floor Deflection (Cont.)

Figure 4

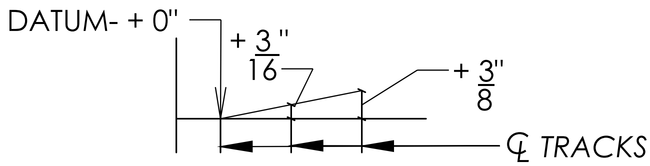




FLOOR FRAMING PLAN



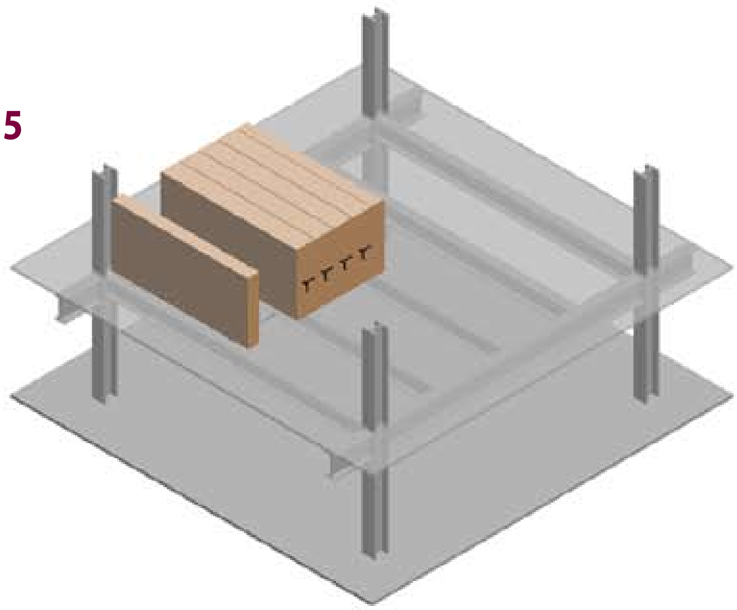
ANTICIPATED FLOOR & BEAM DEFLECTION

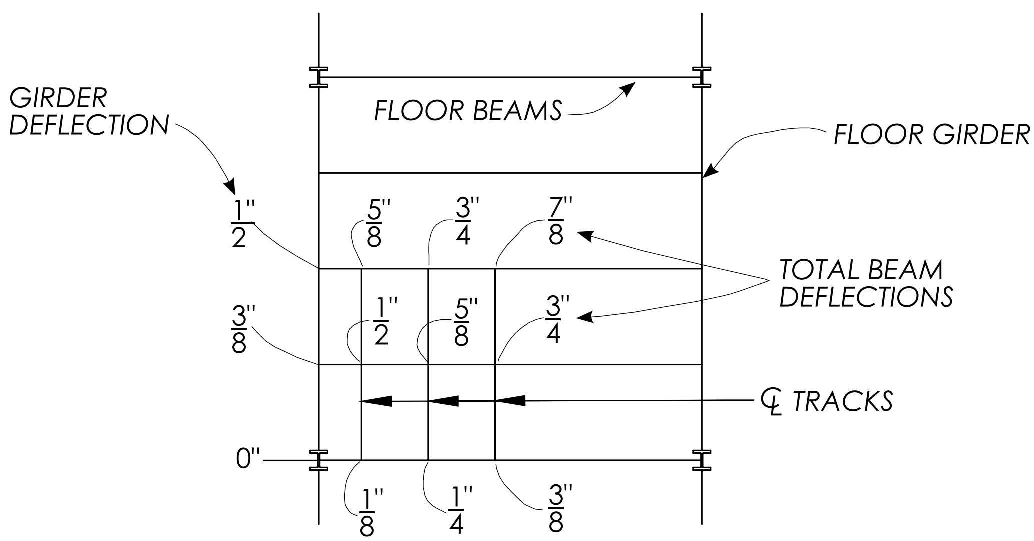


TRACK STEPPING

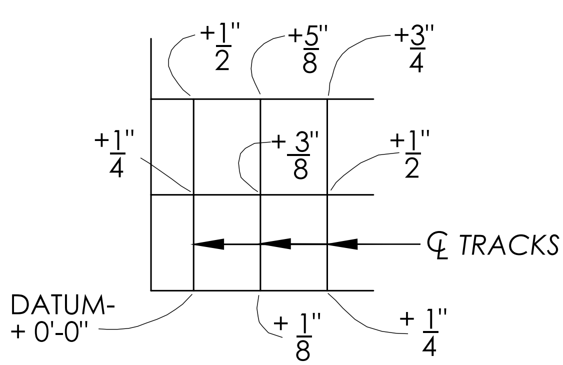
After the shelving is loaded the carriage will have a slight slope of 1/8". This will not interfere with the operation of the CMFS.

Figure 5





FLOOR FRAMING WITH ANTICIPATED LL DEFLECTIONS (EXAMPLE)



TRACK GROUTING ELEVATIONS (EXAMPLE)

Tracks are set 1/8" less than the Maximum total deflection at the center support to account for more open filing space and underestimating actual floor stiffness.

Tracks are straight & evenly stepped so that carriages will roll properly

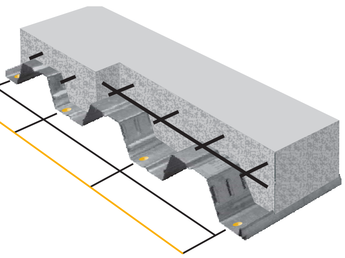
Metal Decking & Concrete Fill

Most contemporary office buildings use a composite metal decking with steel beams and normal weight or light weight concrete fill. Beam spacing is typically from 8 ft. to 11 ft. Concrete and metal decking slabs usually have a live load carrying capacity in excess of 200 lbs./sq. ft. A wide continuous flat steel plate under the track can be used to spread the load out so that the entire concrete slab can help support the track load. Typically the EI of the slab will be much larger than the EI of a similar shallow steel track beam. This solution has been successfully used for light loads for carriages less than 30 in. in width. See example on next page.

Chart A

PLW3™ and W3 FORMLOK™

- **6¼ in. (*159 mm*) TOTAL SLAB DEPTH**
- **Light Weight Concrete**
  110 pcf (*1,760 kg/m*^{3})
  43.5 psf (*2,083 N/m*^{2})
- **Galvanized or Phosphatized/Painted**
- **2 Hour Fire Rating**



Deck Weight and Section Properties

Gage	Weight (psf, *N/m²*) Galv G60 *Z180*	Weight Phos/ Painted	Properties per ft (*m*) of Width: I in.^{4} *mm*^{4}	+S in.^{3} *mm*^{3}	–S in.^{3} *mm*^{3}	Allowable Reactions per ft (*m*) of Width (lb, *N*): End Bearing 2" *51 mm*	End Bearing 3" *76 mm*	End Bearing 4" *102 mm*	Interior Bearing 4" *102 mm*	Interior Bearing 5" *127 mm*
22	1.9 *91.0*	1.8 *86.2*	0.718 *980,492*	0.418 *22,473*	0.444 *23,871*	190 *2,773*	228 *3,327*	267 *3,897*	601 *8,771*	701 *10,230*
21	2.1 *100.5*	2.0 *95.8*	0.837 *1,142,997*	0.495 *26,613*	0.531 *28,548*	240 *3,503*	286 *4,174*	331 *4,831*	781 *11,398*	906 *13,222*
20	2.3 *110.1*	2.2 *105.3*	0.896 *1,223,567*	0.534 *28,709*	0.564 *30,322*	268 *3,911*	316 *4,612*	365 *5,327*	877 *12,799*	1014 *14,798*

Allowable Superimposed Loads (psf, *kN/m*^{2})

W3 6¼" LW

Gage	Spans	Span (ft-in., *mm*) 8'-0" *2,440*	8'-6" *2,590*	9'-0" *2,740*	9'-6" *2,900*	10'-0" *3,050*	10'-6" *3,200*	11'-0" *3,350*	11'-6" *3,510*	12'-0" *3,660*	12'-6" *3,810*	13'-0" *3,960*	13'-6" *4,110*	14'-0" *4,270*	14'-6" *4,420*	15'-0" *4,570*
22	1	309 *14.8*	279 *13.4*	213 *10.2*	191 *9.1*	172 *8.2*	155 *7.4*	141 *6.8*	128 *6.1*	116 *5.6*	106 *5.1*	97 *4.6*	88 *4.2*	81 *3.9*	74 *3.5*	68 *3.3*
	2	309 *14.8*	279 *13.4*	254 *12.2*	232 *11.1*	172 *8.2*	155 *7.4*	141 *6.8*	128 *6.1*	116 *5.6*	106 *5.1*	97 *4.6*	88 *4.2*	81 *3.9*	74 *3.5*	68 *3.3*
	3	309 *14.8*	279 *13.4*	254 *12.2*	232 *11.1*	213 *10.2*	196 *9.4*	141 *6.8*	128 *6.1*	116 *5.6*	106 *5.1*	97 *4.6*	88 *4.2*	81 *3.9*	74 *3.5*	68 *3.3*
21	1	341 *16.3*	309 *14.8*	281 *13.5*	256 *12.3*	194 *9.3*	176 *8.4*	160 *7.7*	145 *6.9*	133 *6.4*	121 *5.8*	111 *5.3*	102 *4.9*	93 *4.5*	86 *4.1*	79 *3.8*
	2	341 *16.3*	309 *14.8*	281 *13.5*	256 *12.3*	235 *11.3*	217 *10.4*	160 *7.7*	145 *6.9*	133 *6.4*	121 *5.8*	111 *5.3*	102 *4.9*	93 *4.5*	86 *4.1*	79 *3.8*
	3	341 *16.3*	309 *14.8*	281 *13.5*	256 *12.3*	235 *11.3*	217 *10.4*	201 *9.6*	186 *8.9*	133 *6.4*	121 *5.8*	111 *5.3*	102 *4.9*	93 *4.5*	86 *4.1*	79 *3.8*
20	1	357 *17.1*	323 *15.5*	294 *14.1*	268 *12.8*	246 *11.8*	186 *8.9*	169 *8.1*	154 *7.4*	141 *6.8*	129 *6.2*	118 *5.6*	108 *5.2*	100 *4.8*	92 *4.4*	84 *4.0*
	2	357 *17.1*	323 *15.5*	294 *14.1*	268 *12.8*	246 *11.8*	227 *10.9*	210 *10.1*	154 *7.4*	141 *6.8*	129 *6.2*	118 *5.6*	108 *5.2*	100 *4.8*	92 *4.4*	84 *4.0*
	3	357 *17.1*	323 *15.5*	294 *14.1*	268 *12.8*	246 *11.8*	227 *10.9*	210 *10.1*	195 *9.3*	182 *8.7*	129 *6.2*	118 *5.6*	108 *5.2*	100 *4.8*	92 *4.4*	84 *4.0*

Shoring required in shaded areas to right of heavy line

Diaphragm Shear Values, q (plf, *kN/m*)

Gage	Welds	Span (ft-in., *mm*) 8'-0" *2,440*	8'-6" *2,590*	9'-0" *2,740*	9'-6" *2,900*	10'-0" *3,050*	10'-6" *3,200*	11'-0" *3,350*	11'-6" *3,510*	12'-0" *3,660*	12'-6" *3,810*	13'-0" *3,960*	13'-6" *4,110*	14'-0" *4,270*	14'-6" *4,420*	15'-0" *4,570*
22	q3	1705 *24.88*	1690 *24.66*	1680 *24.52*	1670 *24.37*	1660 *24.23*	1650 *24.08*	1645 *24.01*	1635 *23.86*	1630 *23.79*	1625 *23.72*	1620 *23.64*	1615 *23.57*	1610 *23.50*	1605 *23.42*	1600 *23.35*
	q4	1780 *25.98*	1760 *25.69*	1740 *25.39*	1725 *25.17*	1710 *24.96*	1695 *24.74*	1680 *24.52*	1670 *24.37*	1660 *24.23*	1650 *24.08*	1640 *23.93*	1630 *23.79*	1620 *23.64*	1615 *23.57*	1610 *23.50*
21	q3	1705 *24.88*	1690 *24.66*	1680 *24.52*	1665 *24.30*	1655 *24.15*	1645 *24.01*	1635 *23.86*	1630 *23.79*	1620 *23.64*	1615 *23.57*	1610 *23.50*	1605 *23.42*	1600 *23.35*	1595 *23.28*	1590 *23.20*
	q4	1810 *26.41*	1790 *26.12*	1770 *25.83*	1750 *25.54*	1730 *25.25*	1715 *25.03*	1700 *24.81*	1685 *24.59*	1670 *24.37*	1660 *24.23*	1650 *24.08*	1640 *23.93*	1630 *23.79*	1620 *23.64*	1610 *23.50*
20	q3	1710 *24.96*	1695 *24.74*	1680 *24.52*	1665 *24.30*	1655 *24.15*	1645 *24.01*	1635 *23.86*	1630 *23.79*	1620 *23.64*	1615 *23.57*	1605 *23.42*	1600 *23.35*	1595 *23.28*	1590 *23.20*	1585 *23.13*
	q4	1830 *26.71*	1805 *26.34*	1780 *25.98*	1760 *25.69*	1740 *25.39*	1720 *25.10*	1700 *24.81*	1690 *24.66*	1680 *24.52*	1665 *24.30*	1650 *24.08*	1640 *23.93*	1630 *23.79*	1620 *23.64*	1610 *23.50*

PLW3 and W3 FORMLOK decks with structural concrete fill may be considered rigid diaphragms, with F < 1 (*5.7*).

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The slab should be checked for deflection. Some metal deck manufacturers have analyzed their deck for various thickness and strengths of concrete. Refer to their values and average the cracked and un-cracked Moment of Inertia, or I_{ave}. This is believed to be conservative since an open aisle (less load) has not been considered in the stress or deflection calculations. For light loads, slab deflection is usually not critical.

CMFS ON COMPOSITE METAL DECKING

DECK SPAN = 10'-0"

EX. DECK'G IS 21 GA. W3 VERCO FORMLOK W/ 3 1/4" LT. WT. CONC.

SEE CHART A - $W_{all} = 235\#/\square'$

ASSUME 10#/□' FOR M.E.P. SUSPENDED FROM UNDERSIDE OF DECKING

$\therefore W_{AVAIL\ LL} = 235^{\#} - 10^{\#} = 225\#/\square'$

CMFS IS 7-LEVEL LETTER PAPER FILE SYSTEM

USE 4'-2 3/4" TRACK SPACING. SEE FLOOR LOADING CHART.

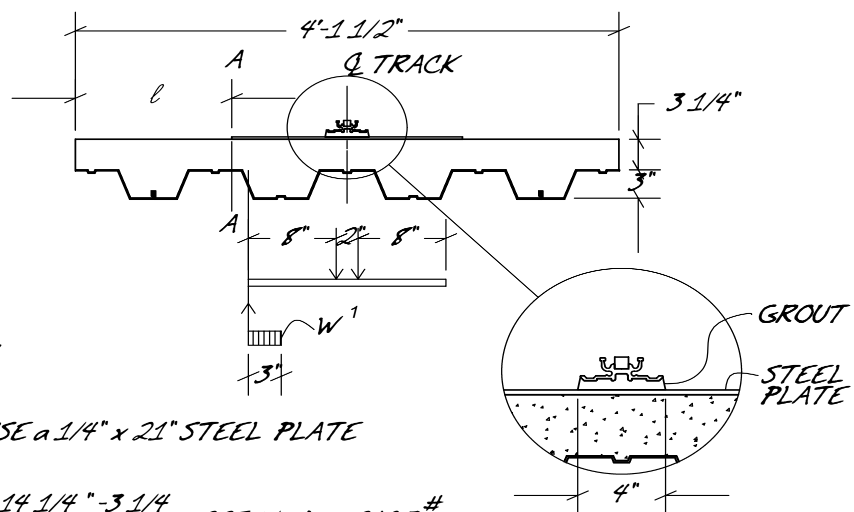
$W_{REQ'D} = 927^{\#}/'$

REQ'D SLAB WIDTH $= \dfrac{927}{225} = 4.12' = 4'\text{-}1\ 1/2" < 4'\text{-}2\ 3/4"$

$\therefore$ SLAB CAPACITY OK

ASSUME 1/4" THICK x 18" CONT. STEEL PLATE TO SPREAD LOAD OUT TO ENTIRE CONCRETE SLAB & DECKING.

CHECK A-A FOR SLAB BENDING & SHEAR - USE ASD



$\ell = \dfrac{4'\text{-}1" - 18"}{2} = 15.5"$

$W_{net} = \dfrac{15.5 - 3.25}{12} \times 225^{\#} = 230^{\#}$

$M_{AA} = (3.25 + \dfrac{12.25}{2})\ 230 = 2156\ "\#$

$S = \dfrac{3.25^2}{6} \times 12 = 21.1\ in.^3$

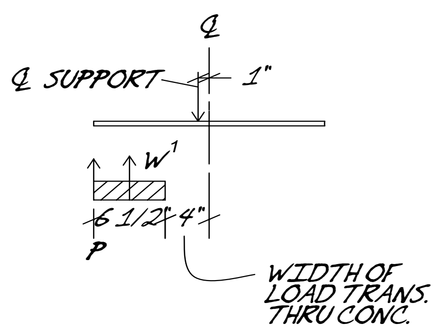
$f'_c = 0.85 \times 2\ \sqrt{f'c} = 1.7\sqrt{3000} = 93.1$ LT. WT. CONC.

$\therefore M_{all} = 21.1 \times 93.1 = 1964\ "\#$ $\therefore$ USE a 1/4" x 21" STEEL PLATE

$\ell = \dfrac{4'\text{-}1/2" - 1'\text{-}9"}{2} = 14\tfrac{1}{4}"$ $W_{net} = \dfrac{14\ 1/4" - 3\ 1/4}{12} \times 225\#/\square' = 206.3^{\#}$

$M_{AA} = 206.3\#\left(\dfrac{11}{2} + 3\tfrac{1}{4}\right) = 1805\ "\# \ll 1964\ "\#$ $\therefore$ CONC OK

CHECK STEEL PLATE FOR BENDING



$P = \dfrac{14.25"}{12"} \times 225\#/\square' = 267^{\#}/'$

$W = \dfrac{6.5"}{12} \times 225\#/\square' = 121.9^{\#} \hat{=} 122^{\#}$

$M = 267^{\#} \times (10.5" - 1") + 122^{\#}\left(\dfrac{6.5}{2} \overset{6.25"}{+4-1}\right) = 3300\ "\# = 3.30\ "\#$

$S_{PL} = \dfrac{12}{6} \times .25^2 = 0.125\ in.^3$

$F = .75\ Fy = .75 \times 36 = 27\ kSI$

$M_{all} = .125 \times 27 = 3.38\ "k/' > 3.30\ "k$

$\therefore$ USE a 1/4" PL - Fy = 36 kSI min. $\therefore$ USE a 1/4" PL x 21" WIDE $Fy_{min} = 36\ kSI$

New Structure Design Criteria Guideline Supporting a CMFS

New building design offers the architect and engineer the ability to provide for the heavy weight of a CMFS. Composite concrete – steel beam systems are most efficient due to the large increase in moment of inertia gained at minimal cost. The most efficient structural system will be to use fewer large beams in order to control beam deflections. A CMFS can also be supported on a system of steel beams without a floor load slab. As column spacing increases, floor beam deflection becomes more critical.

The final track deflection often designs the beams. Some benefit can be obtained by cambering the tracks based upon a realistic live load beam deflection. See Floor Beam and Girder Analysis. Cambering the steel beams can be used if the cambering is coordinated with TAB's factory personnel.

CMFS carriages will drift based upon floor slope. For simple beams, maximum slope occurs at beam ends. Providing continuity, end restraint, and welding plates or Tee beams to the bottom flange of the steel beam will all help control deflection. Continuity for deflection control can be achieved at beam ends by adding reinforcing steel in the concrete slab. Even nominal slab reinforcing (#6 bars @ 6" o.c.) will have a significant impact on floor deflection. The challenge will be to obtain the stiffest members within the available space.

Structural engineering practice generally relies upon a deflection criteria of L/x. Floor slope is critical and not total floor deflection. For 20 ft. long beams, drift may be controlled by using a deflection criteria of L/480. For a 35 ft. span beam, L/800 is more appropriate. Beam deflection should be calculated using actual loads (point load and/or uniform loads) and stiffness is based upon the full slab width of composite slabs. Increasing concrete slab strength to 4.0 KSI can also help. In any case, floor slope should be reviewed and kept under 3/16" in 8ft.

Deflection Criteria Guideline				
	Span			
Up to:	21'	26'	30'	35'
L =	252"	312"	360"	420"
Use:	L/480	L/600	L/700	L/800

* Use this table as a guideline, as the CMFS may not lead the floor evenly across the span.

Steel Beam Design

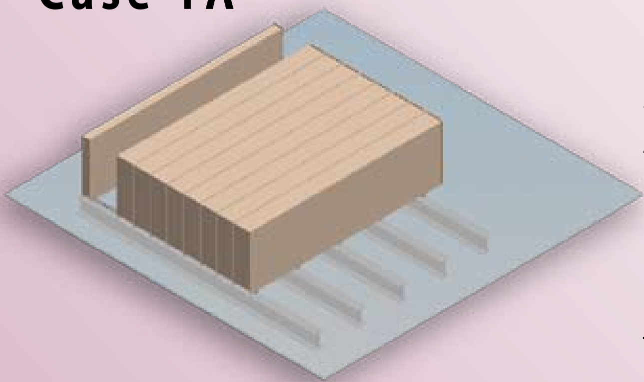
Design a steel beam system to support a CMFS without a concrete or metal deck floor.

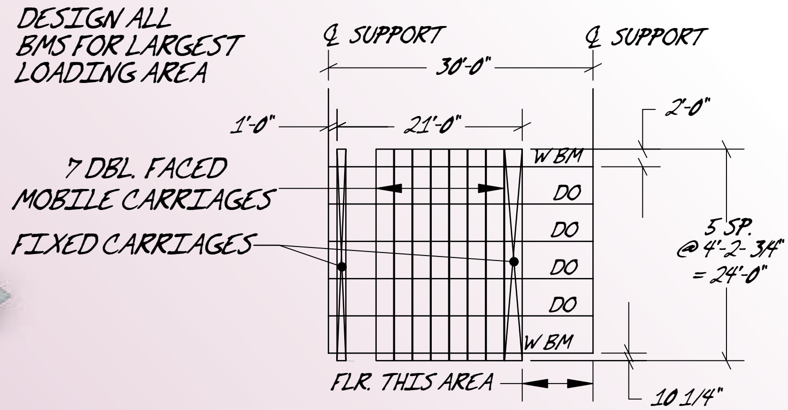
Criteria:

1. **Beam span is 30'-0"**
2. **CMFS is a 7 level letter system with seven 24'-0" long movable carriages, 1 single faced fixed carriage and 1 double faced fixed carriage.**
3. **Case 1 beams are placed under tracks at 4'-2 ¾" oc.**
4. **Case 2 beams are placed 4'-0" oc perpendicular to tracks.**
5. **Check BM deflection and stress.**
6. **All beams are simply supported. Use F_Y = 36 KSI or F_Y = 50 KSI**
7. **Steel BMS to support files and decking. Access floor system weight is assumed to be 50#/sq. ft. LL, 50#/sq. ft. DL, 10#/sq. ft. M.E.P. and 20#/sq. ft. partition.**
8. **Since the actual loading in the file system is not really precise, minor approximations in the design is appropriate. It is always better to use larger members, especially for spans longer than 35' in order to control deflection.**

Case 1 Loading Plan Examples

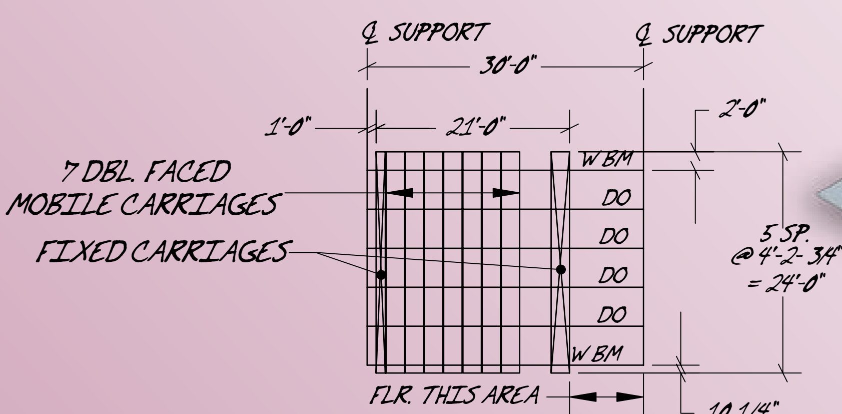
Case 1A



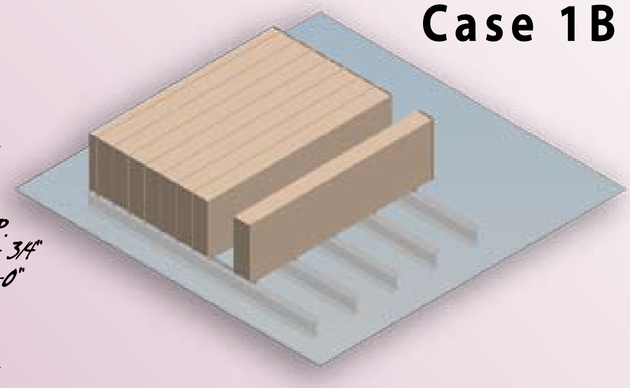


CASE 1A - All MOBILES AT RIGHT SIDE
BEAMS UNDER TRACKS

Case 1B

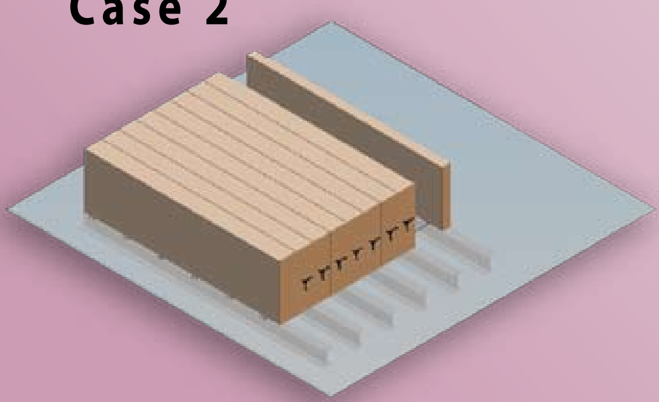


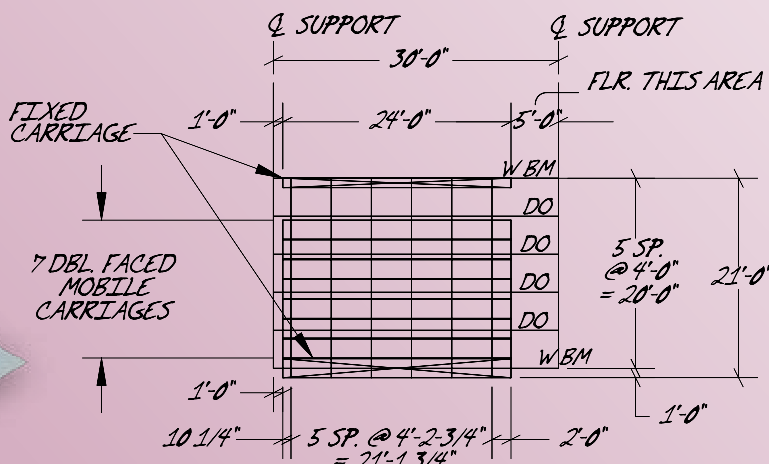
CASE 1B - All MOBILES AT LEFT SIDE
BEAMS UNDER TRACKS



Case 2 Loading Plan Example

Case 2





CASE 2 - TRACKS PERPENDICULAR TO BEAMS
TRACKS SUPPORTED BY SECONDARY BEAMS

CASE 1 30' BEAMS UNDER TRACKS.

CMFS DESIGN LOAD = 927#/' (SEE DESIGN LOADING CHART
ASSUMED BM DL 73 7-LEVEL LETTER PAPER &
CMFS TOTAL LD = 1000#/' 4'-2 3/4" TRACK SPACING)

FLOOR AREA -
$W_{FLR\ D+L} = 4.23 \times 130\#/' + 73\#/' = 623\#/'$ SAY 625 #/'

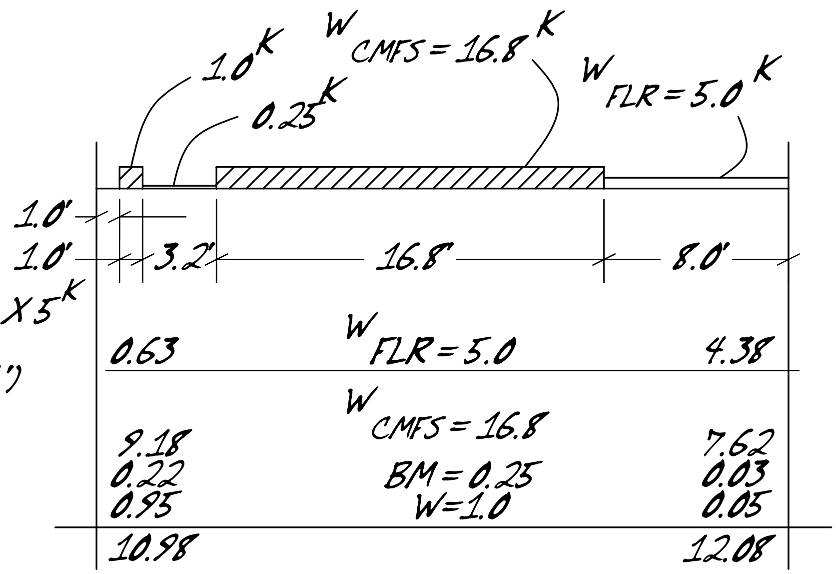
CASE 1A

V = 0 @ 15.08' from right

$\therefore M_{max} = 12.08^K \times 15.08' - (11' \times 5^K + 7.08^2 \times 1^K/')$

$= 182.2 - (55 + 25.1)$

$M_{max} = 102.1^{K'}$



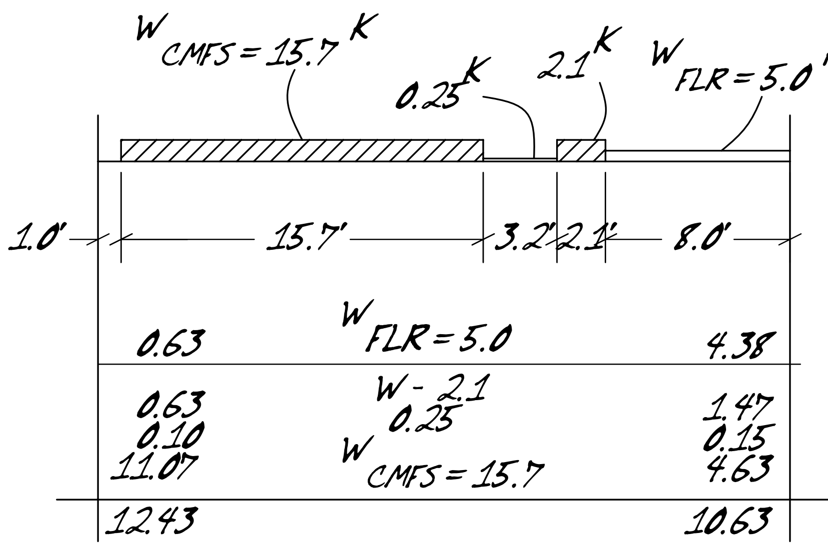
CASE 1B

V = 0, X = 13.43' from left

$M = 12.43^K \times 13.43' - \frac{12.43^2}{2}$

$= 166.9 - 77.2$

$= 89.7^{k'}$



CASE 1A CRITICAL $S_{min} = 51\ in^3$

Case 1 & Case 2 Steel BMS

For deflection, most of the loading is either dead load or from the CMFS. Use the entire load and since case 1A and case 1B have similar beam reactions, assume uniformly loaded simple span beam.

REDUCE COMPACT FILE LL BY 15% FOR ACTIVE FILE SYSTEM

$$\therefore W_{\Delta TL} = 23.06 - 17.08' \; \frac{(4.23' \times \underbrace{0.15 \times 336\#/'}_{\text{FILE LL}})}{\underbrace{2.10'}_{\text{CARRIAGE WIDTH}}}$$

$$= 23.06 - 0.71$$

$$W_{\Delta TL} = 22.35^K$$

$$\therefore \Delta = \frac{22.35^K \times 30^3 \times 7.50 \times 10^{-4}}{843} = 0.54''$$

MAX. SLOPE = 3/16"/8'-0" $\therefore \Delta_{℄} = .375''$ OR $\Delta_{MAX} = L/800 = 0.45''$

$I_{req'd} = \frac{0.54''}{0.375''} \times 843 = 1214$ SAY W21 X 57 $I = 1170 \, in^4$

$\Delta_{act} = 0.39''$ OK $S = 111 >> 51 \, in^3$

NOTE - COMPR. FLANGE MUST BE BRACED

BM. WT. ALLOWANCE = 73#/' > 57# $\therefore$ W21 x 57 OK

ALTERNATE - USE W18x71 ($I = 1170 \, in^4$)

CASE 2 SEE SKETCH

TRACKS MUST BE SUPPORTED BY SECONDARY MEMBERS I.E: TUBES.
SEE REINFORCEMENT DESIGN CHART" & "DESIGN LOADING CHART"

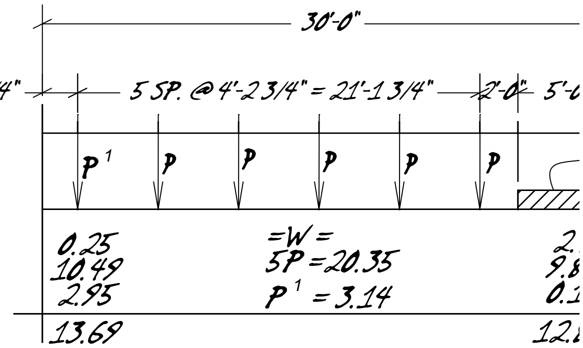
BEAM SPACING IS 4'-0" OC.
MAX WHEEL LOAD FOR 7-LEVEL LETTER PAPER FILE SYSTEM FOR TRACKS AT 4'-2 3/4" OC IS 975 #

FROM REINFORCEMENT DESIGN CHART, MIN. TUBE SIZE IS TS6x2x3/6
$(P_{MAX} = 1200\# > 975\#)$

USE A TS6x2x3/6 X 9' & 12' LONG EA. TRACK (6 PLACES)

CASE 2 - STEEL BEAM

BEAM DESIGN



$$W_{FLR} \hat{=} 4'(130\#/') + \overbrace{75\#/'}^{BM\ DL}$$

$$= 595 = 600\#/'$$

$$P \hat{=} 4'(\underbrace{927\#/'}_{\text{TRACK LOAD FOR 7-LEVEL LETTER PAPER FILE, TRACKS @ 4'-2 3/4" OC}} + \overbrace{10\#/'}^{TS6x2}) + 4.23' \times 75\#/' \,(BM\ DL) = 3750 + 320 = 4.07^K$$

$$P' \hat{=} 4'(\underbrace{927\#/' \times 0.75}_{\text{APPROX. CMFS TRACK LD}} + 10\#/') + 4.23' \times 75\#/' = 3.14^K$$

V = 0 @ X = 14.54' FROM LEFT SIDE

$$M_{MAX} = 13.69^K \times 14.54' - (12.69' \times 3.14^K + 6.34' \times 4.07^K \times 2)$$

$$= 199^{K'} - (39.8 + 51.6) = 107.6^{K'}$$

$$S_{MIN} = 54$$

SINCE POINT LOADING IS SO CLOSE TOGETHER, A UNIFORM LOAD DEFLECTION ANALYSIS IS APPROPRIATE.

REDUCE LIVE LOAD PORTION OF CMFS 15% TO REFLECT AN ACTIVE MOBILE SYSTEM.

$$\therefore \text{LL REDUCTION} \hat{=} \frac{.15 \times \overbrace{336}^{LL}}{\underbrace{461}_{TL} + \underbrace{10}_{TS} + \underbrace{75}_{W}} = \frac{50}{546} = .0916$$

$$\therefore \Sigma W = 26.49^K \overbrace{(1 - .0916)}^{.9084}$$

$$= 24.06^K$$

$$\Delta = \frac{24.06 \times 30^3 \times 7.5 \times 10^{-4}}{\underbrace{1170}_{W21x57}} = 0.42"$$

$$\Delta = \frac{L}{800} = \frac{30 \times 12}{800} = 0.45" > 0.42$$

SINCE TRACKS ARE PERPENDICULAR TO BEAMS, BEAM DEFLECTION AFFECTS CARRIAGE SHAPE.

CARRIAGE CAN CONFORM TO L/800 SHAPE.

$$\therefore I_{MIN} = \frac{.42}{.45} \times 1170 = 1092\ in.^4$$

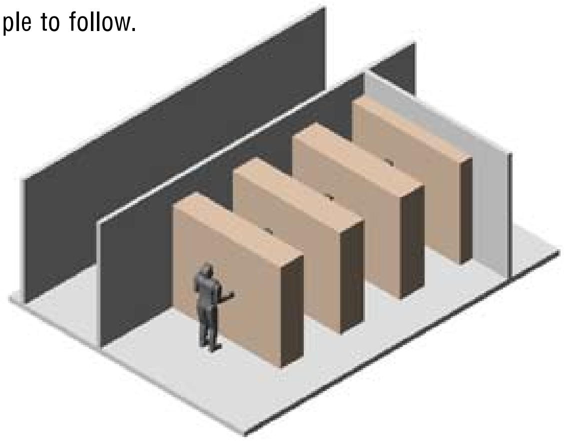
$$\therefore W21x57 \text{ OR } W18x65 - S_{MIN} = 111\ in^3 \quad I_{MIN} = 1070\ in.^4$$

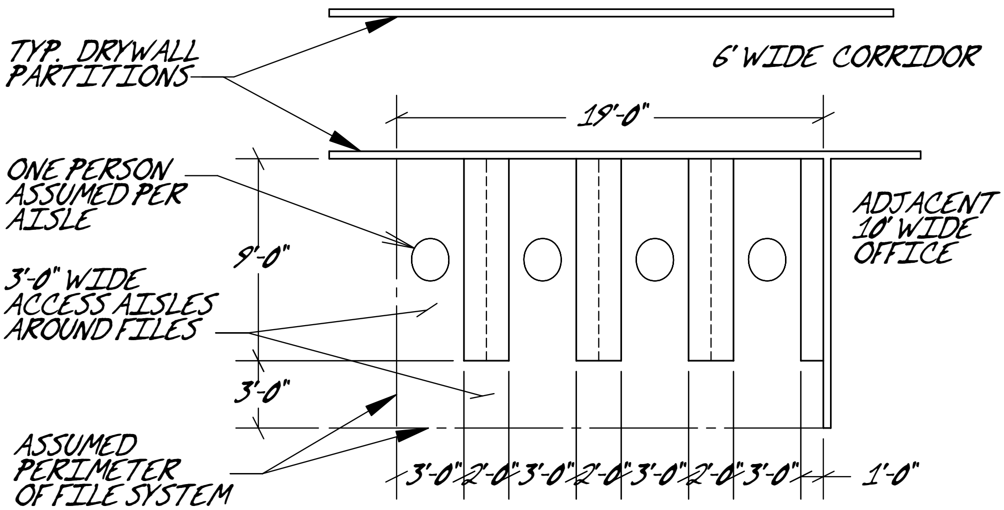
NOTE! BEAMS REQUIRE COMPRESSION FLANGE BRACING.

Static Shelving

Static shelving often occurs adjacent to a CMFS. Checking the structure for the support of static shelving commonly uses an equivalent uniform load approach since the shelving bears directly upon the floor. A typical static file system has one to two people per aisle for a design load criteria. The total load of the static shelving system should also include any walls, equipment, etc. within or contiguous to the static files. The floor area for a static system will include both internal and exterior access aisles. See figure 6 and static live load example to follow.

Figure 6





TYPICAL FILE SYSTEM IN PART OF A LARGER OFFICE

COMPUTE FLOOR LOAD IN 12' X 19' FILE AREA

FILES ARE 8-LEVEL LETTER FILES CONTAINING PAPER MEDIA

FILE DEAD LOAD - 75#/LIN. FT. DOUBLE-FACED FILES
45#/ LIN. FT. SINGLE-FACED FILES

PAPER MEDIA - 24#/ LIN. FT.

TOTAL LIVE LOAD -

FILES - 9'[3(75#/' + 24#/' X 2 X 8) + 45#/' + 8 x 24#/']
= 9'[3 X 459 + 237 = 1614] = 14,526
PEOPLE - 4 X 200# EA. = +800
15,326

$$LL\ (W/O\ PARTITION\ LD.) = \frac{15326\#}{12' \times 19'} = 67.2\#/\square'$$

$$PARTITION\ LOAD = \frac{9'\ HT \times 10\#/\square'}{12 + 6/2} + \frac{9' \times 10/\square'}{19 + 10/2} = 6 + 4 = 10$$

TOTAL AVERAGE FLOOR LOAD = 67.2 + 10 = 77.2 #/□'

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Increase information access and productivity.

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