STRUCTURAL CLAY TILE

Fireproof Floor Systems

Hollow Tile Arches. Hollow tile arches usually fill the total depth of the floor beams, and therefore tend to stiffen and brace the building; their weight per square foot is light as compared with other forms of fireproof floor construction of equal strength. Hollow tile floor arches are made either flat or segmental. The segmental arch will develop much greater strength than the flat arch of the same width and depth but, because of the irregular ceiling obtained, is not so generally used. It is not considered in this condensed treatise, but design data may be obtained from the Structural Clay Tile Association or from the publications of clay tile manufacturers.

Thrust of Floor Arches. All forms of hollow tile arches produce side thrust on the floor beams. In the flat arch the blocks have tapered faces and the central block or key wedges the others together; in the segmental arch the thrust is that due to all arch action. It is necessary to counterbalance these thrusts by means of tie rods connecting the webs of the floor beams. In the central bays, owing to the action of adjacent arches, the tie rods are sometimes omitted, but it is necessary to investigate outer beams and channels around openings for additional thrust stresses so that the combined unit stresses produced by vertical loading and horizontal thrusts may not be excessive. With flat arches, ¾-inch tie rods, spaced not over fifteen times the width of the beam flanges, will usually be sufficient. The total thrust of arch, the net area of tie rods required, the maximum distance between tie rods and the section of outer beams for any condition, may be found as follows:

Let

w = Unit load on arch, in pounds per square foot.
D = Distance of arch span, in feet.
L = Length of floor beam supporting the arch, in feet.
R = Effective rise of arch, in inches.
p = Thrust of arch per lineal foot, in pounds.
P = Total thrust of arch per panel, in pounds.
A = Total net area of tie rods per panel, in square inches.
a = Net area of one tie rod, in square inches.
T = Spacing of tie rods, center to center, in feet.
f = Allowable combined unit stress, in pounds per square inch.
S_{1-1} = Section Modulus of beam, Axis 1-1, in inches^3.
S_{2-2} = Section Modulus of beam, Axis 2-2, in inches^3.
M_{1-1} = Bending Moment for vertical loading, in inch-pounds.
M_{2-2} = Bending Moment for arch thrust, in inch-pounds.

Then

$$p = \frac{3wD^2}{2R} \qquad P = pL$$

$$A = \frac{3wD^2L}{2fR} = \frac{P}{f}$$

$$T = \frac{2afR}{3wD^2} = \frac{af}{p}$$

$$M_{1-1} = \frac{12L\ (\frac{1}{2}wDL)}{8} = \frac{3wD\ L^2}{4}$$

$$M_{2-2} = \frac{12T\ (pT)}{12} = pT^2$$

$$f = \frac{M_{1-1}}{S_{1-1}} + \frac{M_{2-2}}{S_{2-2}}$$

In formula given for M_{2-2} the beam is considered continuous, supported at intervals by the tie rods. In segmental arches the effective rise is equal to the vertical distance between highest point of concave surface and springing line or chord; the effective rise of a flat arch may be taken at 2.4 inches less than the arch depth.

The allowable combined unit stress in tie rods should not exceed 18,000 pounds, and tie rods should be placed in line of thrust, usually 3 inches above the bottom of the beam.

Net Areas of Usual Sizes of Tie Rods

Diameter of Rod, Inches	5/8	3/4	7/8	1
Net area, a, square inches...	0.202	0.302	0.420	0.550

EXAMPLE: A floor panel 18 feet by 6 feet, of 12-inch flat terra cotta blocks, is to support a uniform live and dead load of 150 pounds per square foot. Required the total thrust, total area of rods per panel, maximum spacing of rods, and the proper size beam to carry one-half of the panel without lateral support other than the tie rods.

Entire panel load is 18 × 6 × 150 = 16,200 pounds.

Assuming a 10-inch beam, 23.0 pounds, and ¾-inch tie rods, then

Thrust of arch per lineal foot, $p = \frac{3 \times 150 \times 6^2}{2 \times (12 - 2.4)}$ = 844 pounds.

Total thrust of arch, $P = 844 \times 18$ = 15,200 pounds.

Total area of tie rods, $A = \frac{15{,}200}{18{,}000}$ = 0.84 square inches.

Maximum spacing of tie rods, $T = \frac{0.302 \times 18{,}000}{844}$ = 6.44 feet.

Bending Moment, vertical loading, $M_{1-1} = \frac{3 \times 150 \times 6 \times 18^2}{4}$ = 218,700 inch-pounds.

Bending Moment, horizontal thrust, $M_{2-2} = 844 \times 6.44^2$ = 35,000 inch-pounds.

Combined unit stress in beam, $f = \frac{218{,}700}{24.4} + \frac{35{,}000}{4.6}$ = 16,560 pounds.

If tie rods are spaced 6′–0″ centers, then

Bending Moment, horizontal thrust, $M_{2-2} = 844 \times 6^2$ = 30,380 inch-pounds.

Combined unit stress in beam, $f = \frac{218{,}700}{24.4} + \frac{30{,}380}{4.6}$ = 15,560 pounds.

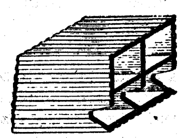
MAXIMUM SPACING IN FEET OF ¾-INCH TIE RODS

For Load of 100 Pounds per Square Foot

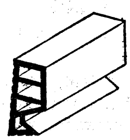
Span, Feet	Effective Rise of Arch, R, in Inches											
	4	5	6	7	8	9	10	11	12	13	14	15
3	16.1											
4	9.1	11.3	13.6	15.8								
5	5.8	7.2	8.6	10.1	11.6	13.0	14.5	16.0				
6	4.0	5.0	6.1	7.1	8.1	9.1	10.0	11.0	12.0	13.0	14.1	15.1
7	...	3.7	4.4	5.2	5.9	6.6	7.4	8.1	8.9	9.6	10.3	11.1
8	...	...	3.4	3.9	4.5	5.0	5.6	6.2	6.7	7.3	7.9	8.5
9	...	...	...	...	3.6	4.0	4.5	4.9	5.4	5.8	6.3	6.7
10	...	...	...	...	...	...	3.6	3.9	4.4	4.7	5.1	5.4

To find spacing of rods for any given loading, multiply tabular values by 100 and divide by the given load per square foot.

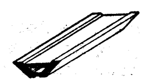
Description of Tile Flat Arches. Flat Arches as adapted to floors and roofs are made up of various shaped tiles as shown below. The tiles resting against the beams are called skews and the soffit tiles, protecting the bottom of the beam, are held in place by the bevel on the skews. The intermediate tiles are called inters, and the center one the key.



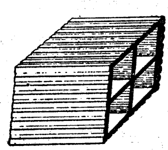
End Construction Skew



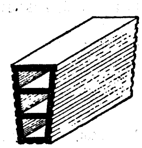
Side Construction Skew



Soffit 2″ thickness, width to suit flange of beam



Inter 8″ or 12″ long

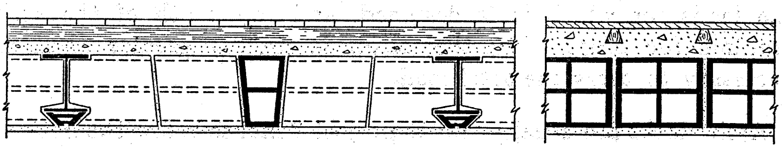


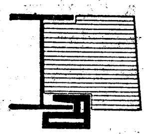
Key

TYPICAL TILES FOR FLAT ARCHES

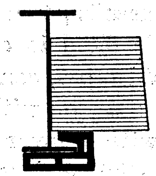
The flat arch has the advantage of light weight and speed in construction. The hung centers are not required for any great length of time and the floors beneath are accessible for work by other trades. The all-tile ceiling provides a good surface for plastering. There are two general types of Flat Arches, namely, the End Construction Flat Arch and the Combination Side and End Construction Flat Arch.

End Construction Flat Arch. This type of Flat Arch consists of end construction skews and inters and side construction keys. This is the most adaptable form of arch, since the end construction skew can be cut to fit different elevations and sizes of beams. It is advisable to keep the bottom flanges of the floor beams as near the same elevation as possible, so that the same bevel which is usually cut for a 2-inch soffit tile may be used throughout and make for uniformity and, therefore, economy of construction. Moreover, this gives a more uniform ceiling level.

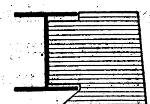




End Construction Skew cut to suit clip tile and flange of beam



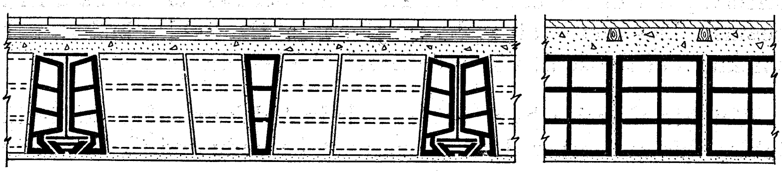
Shows bearing of End Construction Butt Skew on spandrel beam



End Construction Skew cut at top and bottom for wide flange beam

TYPICAL SECTIONS—STANDARD END CONSTRUCTION

Combination Side and End Construction Flat Arch. This type consists of side construction skews and keys and end construction inters.



TYPICAL COMBINATION SIDE AND END CONSTRUCTION FLAT ARCH

By making the cells of the skews parallel to the beams, better protection is given to the sides of the beams by the mortar joints and by the shells of the skews. The inters must be set end to end in straight courses from skew to key. The typical section illustrates the method of assembling the various members of this arch.

Side construction skews are made by die to fit the various size standard beams and cannot be changed as can end construction skews. Dies to make skews to fit standard beam shapes are carried in stock by manufacturers. If it is desired to use side construction skews uniformly throughout a building, the floor beams must be on the same level at the bottom. For special conditions, end construction skews can be used and cut to fit.

Designing Data. The depth of the arch must be proportioned to the span between the beams and, to a certain extent, to the load carried. A safe general rule for finding the depth of the arch in inches is to multiply the span in feet by 1½ and add the thickness of the protection below the beams. This is the general code requirement of the larger cities.

Theoretically, a correctly designed and constructed flat arch will always develop the full strength of the steel beam that supports it. Practically, however, the depth of the floor beam is determined by the loads for which it is designed, and the depth of the arch required for fireproofing the beam is usually greater than is necessary to carry the total load.

Arch blocks are usually laid to project 2 inches below the bottom of the beams, but this thickness is governed by code requirements. The space above the arch is filled in either with a light weight concrete, in which can be laid pipes, conduits, and wooden nailing strips supporting wood flooring, or with thin terra cotta blocks made for this purpose, or with a layer of plastic composition of cement, which forms the wearing surface for the floor.

The following table is applicable to all shapes of tile. Generally, hollow tile of various shapes but of the same depth and net cross-sectional area have equal strengths, so the strengths of arches of equal depth are directly proportional to their net sectional areas. The net sectional areas of tile indicated are for the keys—the critical point of the arch—and are taken per foot of tile parallel to beams. The depth of arch, as given in the table, includes the thickness of the soffit tile underneath the bottom of the beam.

Weights of arches have not been deducted from safe loads in the table; this and other dead loads must be deducted to obtain the net safe live load for any arch or span.

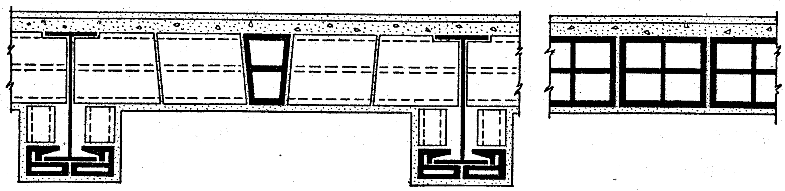
Weights given in the table are for arch in place, including the mortar.

TOTAL SAFE LOADS PER SQUARE FOOT

Dead and Live Loads. Factor of Safety of 7

Arches, In.	8	9	10	12	15
Net Sectional Areas, Sq. In.	27	27	36	36	36
Average Weight, Lbs. per Sq. Ft. of Arch	36	39	42	48	56
Span	Safe Loads in Pounds per Square Foot				
3′-0″	560	630	933	1120	1400
3′-3″	477	537	795	954	1193
3′-6″	411	462	685	823	1028
3′-9″	358	403	597	716	895
4′-0″	315	354	525	630	786
4′-3″	279	314	465	558	697
4′-6″	249	279	415	497	622
4′-9″	223	251	372	447	558
5′-0″	201	227	336	402	504
5′-3″	182	205	305	385	457
5′-6″	...	187	277	333	417
5′-9″	...	171	254	305	381
6′-0″	...	157	233	280	350
6′-3″	...	...	214	258	322
6′-6″	...	...	198	238	298
6′-9″	...	...	...	221	276
7′-0″	...	...	...	206	257
7′-6″	...	...	...	178	223
8′-0″	...	...	...	157	197
8′-6″	...	...	...	...	174
9′-0″	...	...	...	...	155
9′-6″	...	...	...	...	140
10′-0″	...	...	...	...	126

This table should be used as a general guide only, as conditions may make it possible to design more economical arches for a given load than indicated by the table. For example, where a paneled ceiling is not objectionable, a shallow arch may be used on raised tile haunches.



ARCH RAISED ON FLOOR BEAMS FOR PANELED CEILING

The thickness of this arch will be approximately 2 inches less than that shown in the table for the respective span and loading.

Example. Design an arch for a span of 6′-6″ and a load, including plaster, of 150 pounds per square foot. From the table we find that a 10-inch arch with a 2-inch soffit under the beam will carry a total load of 198 pounds per square foot. Deducting 42 pounds, the weight of the arch, gives a capacity of 156 pounds per square foot for the total load. As the effective bearing depth of the 10-inch arch is but 8 inches; it is evident that a raised 8-inch arch, having the same bearing depth, will carry the same load.

Flat Arch is generally sold per square foot of the actual floor area filled by the tile. The design of the floors as to the pieces of the filler tile and the width of the key, which is variable, is furnished by the tile manufacturer to suit the spans and shapes of steel used.

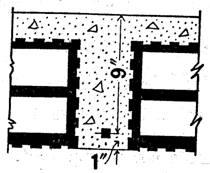
Combination Tile and Reinforced Concrete Ribbed Floor and Roof Construction. This type of floor and roof construction includes systems in which structural clay tile is used as an integral part of the slab, with reinforced concrete ribs running in either one or both directions. If concrete topping is used, the shells of hollow tile in contact with the topping shall be considered as part of the required thickness of top slab, and the shells of hollow clay tile units in contact with concrete in both top slab and ribs shall be included in calculations involving shear and bending. The concrete ribs should be at least 4 inches in width, including tile shells, but this width must be sufficient to allow at least ¾ inch of concrete on either side of reinforcing bars.

These recommendations are based upon Technologic Paper No. 220 of the Bureau of Standards on Tests of Hollow Tile and Concrete Floor Slabs Reinforced in Two Directions, Technologic Paper No. 291 on Tests of Hollow Tile and Concrete Slabs Reinforced in One Direction, and Research Paper, No. 181, on Tests of Composite Beams and Slabs of Hollow Tile and Concrete.

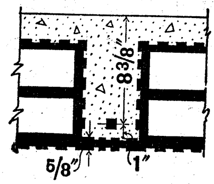
The shells of structural clay tile should be at least ½ inch in thickness.

Combination structural clay tile and concrete floors usually permit of thinner slabs, reduce dead load, and, where plaster is to be applied directly to the slab, provide a good plastering surface. This type of floor offers very high resistance to sound transmission.

When a ceiling with a tile surface over the entire area is required, tile slabs are furnished to be laid between structural clay tiles. These tile slabs are scored on both sides so as to furnish secure bond with the concrete joists and plaster. When the all tile ceiling is employed, the effective depth of the floor is decreased by the thickness of the tile slab in the joist, as illustrated in the sketch below, and to provide necessary strength the floor thickness must be increased.

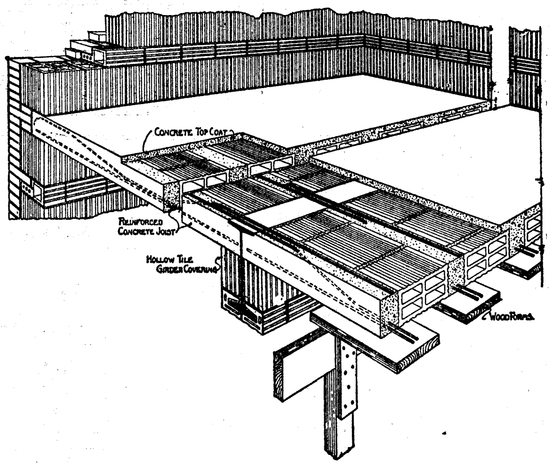


Effective Depth 9"
COMBINATION CEILING



Effective Depth 8⅜"
ALL-TILE CEILING

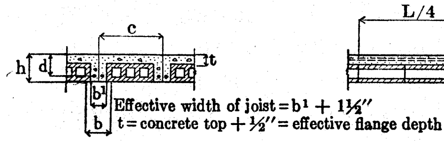
It has been found that an all-tile ceiling is not essential where good construction methods are used for installing the floors, and no stain of the plaster will occur if floor is thoroughly dry before the plaster is applied. Some architects specify that the underside of combination hollow tile and concrete floors shall be sprayed with a coat of mastic preparation to prevent streaks showing through plastered ceilings applied to this type of floor.

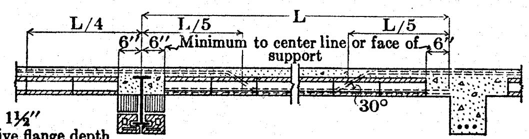


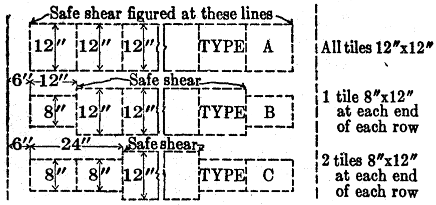
TYPICAL ONE-WAY COMBINATION FLOOR

Note economical wood centering used;
2″ x 8″ or 2″ x 10″ under each joist is sufficient

TILE AND ONE-WAY CONCRETE JOIST SLABS







f_c = 700 lbs. per sq. in.
f_s = 18,000 lbs. per sq. in.
v = 60 lbs. per sq. in., shearing stress
n = 15

Dimensions in Inches

Total Depth, h	Effective Flange Depth, t	Top of Slab to Rods, d	Width of Concrete in Joist, b¹	Center to Center of Joists, c	Weight of Slab, Lbs. per Sq. Ft.	Max. Resisting Moment, Ft.-Lbs.	Area of Steel Reinf., Sq. In.	Round Bars (*Square) b, Bent s, Straight	Total Shear in Lbs. for Each Joist: Type A Construction	Type B & C Construction
3+1½	2	3½	4	16	40	1855	.41	2—½	1030	1750
4+1½	2	4½	4	16	44	3070	.52	1— ½*b 1— ½*s	1300	2250
5+1½	2	5¼	4½	16½	53	4300	.63	1— ⅝ b 1— ⅝ s	1660	2760
6+1½	2	6¼	4½	16½	56	5954	.73	1— ¾ b 1— ⅝ s	1970	3285
6+2	2½	6¾	5	17	62	7285	.82	1— ¾ b 1— ¾ s	2310	3730
7+2	2½	7¾	5	17	71	8900	.88	1— ¾ b 1— ¾ s	2560	4140
7+2½	3	8¼	5	17	76	10900	1.00	1— ⅞ b 1— ¾ s	2820	4550
8+2	2½	8½	5	17	76	11100	1.00	1— ⅞ b 1— ¾ s	2910	4700
8+2½	3	9	5½	17½	82	13220	1.12	1— ⅞ b 1— ¾ s	3320	5200
9+2	2½	9½	5½	17½	82	13660	1.10	1— ⅞ b 1— ¾ s	3500	5500
9+2½	3	10	5½	17½	88	15890	1.21	1— ⅞ b 1— ⅞ s	3690	5800
10+2	2½	10½	5½	17½	89	15880	1.15	1— ⅞ b 1— ⅞ s	3870	6080
10+2½	3	11	5½	17½	94	18600	1.29	1—1 b 1— ⅞ s	4050	6370
12+2	2½	12½	5½	17½	100	20350	1.24	1—1 b 1— ⅞ s	4600	7230
12+2½	3	13	5½	17½	106	23950	1.40	1—1 b 1— ⅞ s	4800	7530

TILE AND ONE-WAY CONCRETE JOIST SLABS

Compressive stress in stem above neutral axis has not been considered.

Floor Slabs should not be less in thickness than ⅜″ for each foot of span.

Floor Slabs should be built with a camber of ¼″ to each 10 feet of span.

Safe loads for WL/8 are for slabs freely supported at each end only.

Safe loads for WL/10 are for slabs freely supported at one end and restrained or continuous over the other end for spans of approximately equal length.

Safe loads for WL/12 are for interior continuous spans of practically equal length only.

Moments of continuous spans of unequal length should be determined and slabs designed accordingly.

Weights of slabs are for plain slab only and do not include anything for finished floor or ceiling.

Loads above and to the right of upper dotted line are under the maximum safe shear resistance for type "A" construction.

Loads between heavy lines produce shear stresses greater than allowed for type "A", but are safe for type "B" construction.

Loads under and to the left of heavy lines produce shear stresses safe for type "C" construction.

Examples are given on following page for using other dimensions and loads.

Moment Factor	MAXIMUM SAFE LOADS IN POUNDS PER SQUARE FOOT																						
	SPAN IN FEET																						
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	28	30
WL/ 8	269	187	134	97	71	52	37																
WL/10	346	244	177	131	99	75	56																
WL/12		*	220	165	127	98	75																
WL/ 8	468	332	244	183	140	108	84	65	51														
WL/10	596	426	316	240	186	146	116	92	74														
WL/12		520	388	299	232	184	148	119	98														
WL/ 8			339	257	197	153	121	95	75	58	45	33	24										
WL/10			437	333	260	205	164	132	107	86	69	55	43										
WL/12			535	409	323	257	207	169	139	114	93	77	62										
WL/ 8			484	374	292	230	184	150	122	99	78	64	50	40	30								
WL/10				479	377	302	244	200	164	136	112	94	77	64	52								
WL/12						374	304	252	210	176	146	124	104	88	74								
WL/ 8					349	277	224	181	148	120	98	80	64	52	40	31							
WL/10					452	362	295	242	200	166	138	116	96	80	66	54	44						
WL/12						447	366	303	252	212	178	152	128	108	92	77	65						
WL/ 8					432	345	277	227	185	152	125	103	84	68	55	43	33	24	16				
WL/10					557	449	364	301	249	208	174	146	123	103	86	71	59	48	38				
WL/12							450	375	313	264	223	189	162	138	117	99	85	71	60				
WL/ 8						432	351	288	238	198	164	137	114	94	78	63	51	40	30				
WL/10						559	458	379	316	266	224	190	161	137	116	98	83	69	57	47			
WL/12										334	284	243	208	180	154	133	115	98	84	72			
WL/ 8						442	360	295	244	202	168	141	118	98	81	66	54	42	33				
WL/10							469	388	324	272	230	196	166	141	120	102	86	72	60	49	40		
WL/12										342	291	249	214	184	159	138	118	102	87	74	63		
WL/ 8						516	421	347	288	240	200	168	141	119	99	82	68	55	44	33			
WL/10							547	454	380	320	271	231	197	169	144	123	105	89	75	62	52	33	
WL/12											342	294	253	219	189	164	142	123	106	91	79	56	
WL/ 8						538	438	362	300	250	211	178	149	125	105	88	70	60	48	38	28		
WL/10							568	473	396	333	284	242	207	177	152	130	108	95	80	68	56	38	
WL/12											358	307	265	228	198	172	146	130	112	98	84	62	
WL/ 8							517	428	357	299	252	214	181	153	130	110	92	76	63	51	41		
WL/10									468	396	337	289	248	213	184	159	137	117	101	86	73	51	33
WL/12													315	273	238	208	182	158	139	121	105	79	57
WL/ 8						631	518	427	356	299	252	213	181	153	129	109	91	76	62	50	40		
WL/10									467	396	337	289	248	213	184	158	136	117	100	85	72	50	31
WL/12													316	273	239	207	181	158	138	120	104	78	55
WL/ 8									427	360	304	259	221	188	161	137	117	99	84	69	57	36	
WL/10										473	404	347	300	259	225	195	170	147	128	110	95	69	48
WL/12														289	253	223	195	172	151	133	102	76	
WL/ 8							676	561	470	396	336	286	244	210	180	153	130	111	94	78	65	42	24
WL/10										520	445	383	330	287	250	216	188	164	142	123	106	78	55
WL/12														320	279	245	217	190	168	147	114	86	
WL/ 8											408	348	299	257	222	192	165	142	122	104	88	61	40
WL/10													400	348	304	266	233	204	179	156	136	103	76
WL/12																266	236	208	184	145	112		

The safe shear on any width of concrete in the joist, other than those given in table on preceding page, is directly proportional to the width.

EXAMPLE. For a 6″ + 1½″ slab where it is desired to make the concrete joist 5 inches wide instead of 4½ inches as shown in the table, the total safe shear resistance is $\frac{5 + 1\frac{1}{2}}{4\frac{1}{2} + 1\frac{1}{2}} \times 1970 = 2134$ pounds for type A construction and would increase in the same proportion for type B and C construction.

If the width of joist is increased, then the distance, c, center to center of joists will increase the same amount, which affects the resisting moment in the same proportion so that for $f_c = 700$ it will be $\frac{17}{16\frac{1}{2}} \times 5970 = 6150$ foot-pounds.

The area of the steel reinforcement is increased in the same proportion and will be $\frac{17}{16\frac{1}{2}} \times 0.73 = 0.75$ square inches.

The required area, A_s, of steel for slabs of the same thickness and with the same width of joist as given in table, but with a lighter load, is directly proportional to the total load.

EXAMPLE. For a 7″ + 2″ slab with a 20-foot span carrying a load of 90 pounds per square foot for WL/12 instead of 117 pounds, the $A_s = 0.88 \times \frac{90 + 71}{117 + 71} = 0.76$ square inches.

WEIGHTS OF STRUCTURAL CLAY TILE FLOOR

Depth of Arch, Inches	Average Weight Lbs. per Square Foot	
	Flat	Segmental
6	26	30
7	29	..
8	32	36
9	35	..
10	38	40
11	42	..
12	50	..

SIZE AND WEIGHT OF TILES
For Combination Tile and Concrete Construction

Size of Tiles, Inches	Minimum No. of Cells	*Standard Weight, Lbs.
3 x 12 x 12	3	15
4 x 12 x 12	3	16
6 x 12 x 12	3	22
6 x 12 x 12	4	25
8 x 12 x 12	4	30
10 x 12 x 12	4	35
12 x 12 x 12	4	40

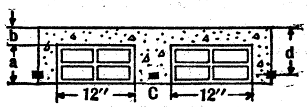
*A tolerance of 5% under or 12½% over will be allowed on the above standard weights. No dimension shall vary more than 3% from the standard for any form of tile.

WEIGHTS OF PARTITION, CEILING, ROOFING AND FURRING TILES

Thickness, Inches	Approx. Weight, Pounds per Sq. Foot				Thickness, Inches	Approx. Weight, Pounds per Sq. Foot			
	Partition	Ceiling	Roofing	Furring		Partition	Ceiling	Roofing	Furring
1½	.....	.....	.....	9	4	16-18	.....	22	.....
2	12-14	12	.....	10	5	18-20	.....	.....	.....
3	15-17	20	20	.....	6	24-26	.....	.....	.....

QUANTITIES OF CONCRETE AND WEIGHT PER SQ. FT.

Of Slab In Combination Floors



Thickness of Concrete and Tile, a + b, Inches	Effective Depth, d, Inches	4″ Joist, C			5″ Joist, C			6″ Joist, C		
		Weight, Lbs. per Sq. Ft.	Quantities		Weight, Lbs. per Sq. Ft.	Quantities		Weight, Lbs. per Sq. Ft.	Quantities	
			Cu. Ft.	Cu. Yd.		Cu. Ft.	Cu. Yd.		Cu. Ft.	Cu. Yd.
4 + 1½	4½	44	.208	.0077	43	.223	.0082	45	.236	.0087
5 + 1½	5½	47	.229	.0085	49	.242	.0091	51	.262	.0097
6 + 1½	6¼	53	.251	.0093	55	.272	.0100	57	.292	.0108
7 + 1½	7¼	58	.271	.0100	60	.296	.0109	63	.320	.0108
8 + 1½	8¼	65	.292	.0108	67	.321	.0118	70	.348	.0129
9 + 1½	9	68	.312	.0115	72	.342	.0127	76	.375	.0139
10 + 1½	10	74	.333	.0123	78	.369	.0136	81	.403	.0149
12 + 1½	12	84	.375	.0138	88	.419	.0155	93	.452	.0167
4 + 2	5	48	.251	.0093	50	.265	.0098	51	.279	.0103
5 + 2	6	53	.271	.0100	55	.290	.0107	57	.303	.0112
6 + 2	6¾	59	.292	.0108	62	.314	.0116	63	.333	.0123
7 + 2	7¾	64	.312	.0115	71	.338	.0125	68	.362	.0134
8 + 2	8¾	71	.333	.0123	76	.363	.0134	76	.390	.0144
9 + 2	9½	74	.353	.0130	78	.388	.0143	81	.416	.0154
10 + 2	10½	80	.375	.0138	84	.412	.0152	88	.445	.0165
12 + 2	12½	90	.417	.0153	95	.461	.0170	99	.506	.0187
4 + 2½	5½	54	.291	.0108	55	.306	.0113	57	.319	.0118
5 + 2½	6½	59	.312	.0115	62	.330	.0122	63	.347	.0128
6 + 2½	7¼	64	.333	.0123	67	.355	.0131	69	.374	.0138
7 + 2½	8¼	70	.353	.0130	76	.379	.0140	75	.402	.0149
8 + 2½	9¼	76	.375	.0138	79	.404	.0149	81	.431	.0159
9 + 2½	10	80	.394	.0145	84	.429	.0158	87	.458	.0170
10 + 2½	11	86	.417	.0153	90	.453	.0167	93	.486	.0180
12 + 2½	13	96	.457	.0169	101	.405	.0187	105	.541	.0200
4 + 3	6	60	.333	.0123	61	.347	.0128	63	.361	.0133
5 + 3	7	65	.353	.0130	67	.372	.0137	69	.389	.0144
6 + 3	7¾	71	.375	.0138	73	.397	.0146	77	.416	.0154
7 + 3	8¾	76	.394	.0145	78	.421	.0155	81	.445	.0165
8 + 3	9¾	82	.415	.0153	85	.446	.0165	88	.472	.0175
9 + 3	10½	86	.436	.0161	90	.470	.0174	92	.500	.0185
10 + 3	11½	92	.457	.0169	96	.494	.0183	99	.528	.0195
12 + 3	13½	102	.499	.0184	107	.544	.0201	111	.583	.0216
6 + 3½	8¼	77	.415	.0153	79	.439	.0162	81	.458	.0170
7 + 3½	9¼	81	.436	.0161	84	.463	.0171	86	.486	.0180
8 + 3½	10¼	88	.457	.0169	92	.488	.0180	94	.514	.0190
9 + 3½	11	92	.478	.0177	96	.513	.0190	99	.542	.0200
10 + 3½	12	98	.499	.0184	102	.537	.0199	105	.570	.0211
12 + 3½	14	108	.541	.0201	113	.586	.0217	117	.625	.0231
8 + 4	10¾	95	.499	.0184	97	.529	.0196	100	.556	.0206
9 + 4	11½	98	.520	.0192	101	.554	.0205	105	.583	.0216
10 + 4	12½	104	.541	.0200	108	.578	.0214	111	.611	.0226
12 + 4	14½	113	.583	.0216	119	.627	.0232	123	.666	.0247

WEIGHTS AND AREAS OF REINFORCEMENT BARS

	Size, Inches	¼	⅜	½	⅝	¾	⅞	1	1⅛	1¼
SQUARE BARS	Area, Sq. In.	.06	...	.25	...	...	...	1.00	1.26	1.55
	Weight, Lbs. per Ft.	.21	...	.86	...	...	...	3.43	4.34	5.35
ROUND BARS	Area, Sq. In.	.05	.11	.19	.30	.44	.60	.78	...	...
	Weight, Lbs. per Ft.	.17	.38	.66	1.05	1.52	2.06	2.69	...	...

Fireproofing of Steel. The purpose of covering beams, girders and columns is to place a fire protection over the structural steel frame of buildings, and to provide a surface on which to plaster.

It is necessary that the steel columns and the girders and beams projecting below the floor slab be protected by at least 2 inches of fireproofing material. In case of a serious fire, the integrity of the whole structure depends upon the thorough protection of the columns, girders and floor beams, and no reasonable expense should be spared to accomplish this. Experience has proven that well-burned structural clay tile (burned at a temperature of about 2000° F.) is an adequate protection for structural steel or iron.

The cement mortar filling the space between the tiles and the steel, protects the steel from corrosion.

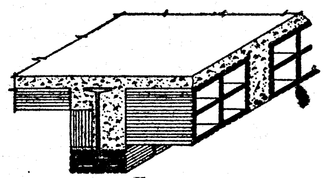


FIG. 1

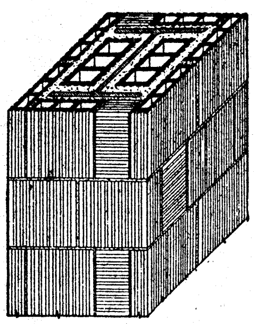


FIG. 2

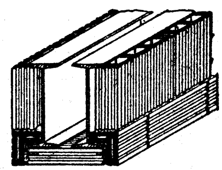


FIG. 3

USUAL METHODS OF PROTECTING STEEL WITH TILE

Tile fireproofing is low in cost, light in weight, can be speedily erected in all kinds of weather, has a good plastering surface and can be obtained in shapes suitable for the widest flange beams. It has ample strength, even with horizontal cell fillers, to carry floor loads of ordinary spans with the factor of safety allowed by building codes. Where the span is long and where there is a considerable load on the floor beam, it is customary to use tile fillers with the cells vertical, which, when filled with concrete, give a continuous solid bearing on the lower flange of the beam.

Girder covering is sold on a basis of the square footage of the actual outside surface of the tile surrounding the beam.

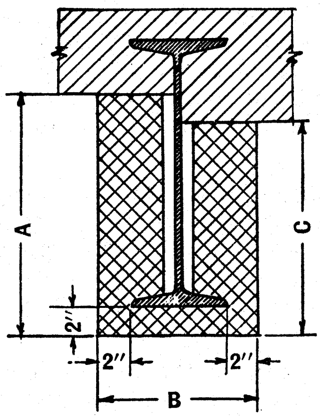


FIG. 4

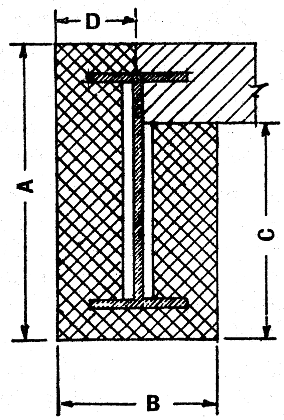


FIG. 5

Estimates can be made of the approximate amount of this tile by taking the linear distance in feet around A+B+C as shown in Fig. 4, or A+B+C+D as shown in Fig. 5, and multiplying this sum by the length of the beam in feet.

In general, the weight of this material will be not over 20 pounds per square foot of superficial surface. However, if concrete is poured into the tile web covering, as is done when tile is used in connection with concrete floor systems, the weight of this concrete must be added.