TABLE X.—COMPRESSION TESTS OF CONCRETE PRISMS.

Lengh 12 inches; Cross Section 6 inches x 6 inches.

Composition.	Age in Days	Compressive Stress, pounds per square inch	Compression in Units of .0008 inch on 8 inches	Coefficient of Elasticity in millions of pounds per square inch	E = T'al Unit Stress / T'al Unit Strain	Breaking Load in pounds per square inch	Reference t oCurve.
					× 10^6		
1	2	3	4	5	6	7	
1 cement, 2 fine Nepean sand, 2 of ¾ in. Nepean shivers	75	373	·62	3·380	4·241	1773	IV. a 1
		1120	3·22	1·650	3·137		
		1493	6·94	·963	1·992		
Ditto	70	373	·52	4·167	5·057	1618	IV. a 2
		747	1·58	3·222	4·031		
		1493	5·30	2·622	2·609		
1 cement, 2 fine Nepean sand, 3 of ¾ in. Nepean shivers	72	373	·56	3·936	4·696	1599	IV. a 3
		747	1·76	3·146	3·618		
		1120	3·22	1·874	3·137		
Ditto	82	373	·64	3·299	4·109	1625	IV. a 4
		747	1·58	2·000	4·031		
		1120	4·72	1·019	2·138		
1 cement, 3 Nepean grit with dust	78	373	1·24	2·000	2·120	1362	IV. a 5
		747	3·76	1·111	1·693		
		1120	8·70	1·516	1 264		
Ditto	69	373	·74	3·070	3·553	1649	IV. a 6
		747	2 20	2·000	2·895		
		1120	4·42	1·275	1·161		
1 cement, 2 sand, 2¾ inch shivers	243	373	·69	3·400	3·811	1518	IV. *a* 1
		1120	3·80	1·740	2·657		
		1493	6·98	1·137	1 983		
Ditto	244	373	·35	6·250	7·513	2638	IV. *a* 2
		1120	2·14	3·000	4·721		
		1493	3·55	2·130	3·897		
		1865	5·35	1·945	3·280		
Ditto	244	373	·46	4·765	5·718	2311	IV. *a* 3
		1120	2·43	2·780	4·157		
		1493	3·96	2·980	3·493		
1 cement, 2 sand, with grit and dust	237	373	·74	5·880	3 553	2030	IV. *a* 4
		1120	4·46	1·760	2 265		
		1493	6·41	1·225	2·157		
Ditto	239	373	·61	3·235	4 310	1936	IV. *B*1
			2·04	2·780	1·287		
			1·81	3 230	1·450		
		1120	3·71	1·720	2·722		
			4·41	6·100	2 290		
			4·44	2·430	2·275		
		1493	6·77	·862	2·402		

TABLE XI.—COMPRESSION TESTS OF CONCRETE PRISMS.

Length 24 inches, kept in air; Cross Section 6 inches x 6 inches.

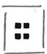
Composition.	Age in Days	Compressive Stress, pounds per square inch	Compression in Units of .0008 inch on 20 inches	Coefficient of Elasticity in millions of pounds per square inch	$E = \frac{\text{T'al Unit Stress}}{\text{T'al Unit Strain}}$ $\times 10^6$	Breaking Load in pounds per square inch	Reference to Curves	Remarks
1	2	3	4	5	6	7	8	9
1 cement, 2 sand, 2¾ in. shivers	84	373 747 1120	2·53 6 97 12·55	2·344 1·975 1·790	2·600 2·285 2·012	1833	IV.b 1	Shattered vertically, about 7 in left sound at one end. Kept in air till tested.
1 cement, 2 sand, 3 ¾ in. shivers	77	373 747 1120	2·80 10·04 29·68	1·762 ·888 ·362	2·347 1·587 ·851	1202	IV. b 2	Shattered vertically in centre.
Ditto	78	373 747 1120	2·50 7·79 14·24	1 756 2·710 ·500	2·630 2·042 1·775	1462	IV. b 3	Broke through the centre, leaving ends sound.
Ditto	84	373 747 1120 1493	2·41 6·87 13·28 25·23	2·530 1 875 1·625 ·422	2·728 2·316 1·900 1·370	1742	IV.b 4	Broke through the centre and one end left sound for 6 in. from end. The rest shattered vertically.
1 cement, 2 grit with dust	78	373 747 1120	2·83 7·97 16·04	2·220 1·600 1·157	2·323 1·996 1·575	1741	IV. b 5	Broke through the centre, both ends sound for 6 inches.
Ditto	81	373 747 1120	3·39 9·81 20·45	1·772 1·280 ·913	1·938 1·624 1·235	1408	IV. b6	Broke near the top, other end sound for about I2 inches.
1 cement, 2 fine Nepean sand, 2 of ¾ in. Nepean shivers; 4 bars  ⅜ in. iron, 15 ties 3-16 in. iron	82	373 747 1120 1493	1·70 5·07 9·55 15·95	3·190 2·488 1·740 1·305	3·868 3·142 2·645 2·165	2427	IV. c 1	Shattered in centre, vertical rods bent; concrete thrown off from outside of bars. Ends left sound.
mixture ditto, 4 bars ⅜ in. iron, 10 ties 3-16 in. iron	63	373 747 1120 1493	2·06 5·81 10·95 18·21	2·860 2·260 1·605 1·250	3·192 2·740 2·310 1·897	2171	IV. c 2	Ditto.
Mixture ditto, 4 bars ⅜ in. iron, 5 ties 3-16 in. iron	63	373 747 1120	1·43 5·31 9·24	2·890 2·090 1·352	4·508 2·999 2·732	1842	IV. c 3	Ditto.
Mixture ditto, 4 bars ⅜ in. iron, 2 ties 3-16 in. iron	64	373 747 1120	1·85 4·70 8·28	3·190 2·900 2·488	3·553 3·388 3·050	2551	IV. c 4	Ditto, but concrete thrown off one end also.
1 cement, 2 fine Nepean sand, 3 of ¾ in. shivers; 4 bars ⅜ in. iron 15 ties 3-16 in. iron	64	373 747 1120	3·09 7·86 16·86	2·073 1·465 ·793	2·126 2·026 1·496	2047	IV. c 5	Ditto, but both ends sound.
Mixture ditto, 4 bars ⅜ in. iron, 5 ties 3-16 in. iron	64	373 747 1120	2·88 8·43 15·88	1·888 1·490 1·038	2·283 1·888 1·590	1726	IV. c 6	Shattered near one end, other end sound for 12 inches. Concrete off rods. Vertical rods bent.

TABLE XI.—Continued.

Composition.	Age in Days	Compressive Stress, pounds per square inch	Compression in Units of .0008 inch on 20 inches	Coefficient of Elasticity in millions of pounds per square inch	E = T'al Unit Stress / T'al Unit Strain	Breaking Load in pounds per square inch	Reference to Curves	Remarks
					$\times 10^6$			
1	2	3	4	5	6	7	8	9
1 cement, 2 fine Nepean sand, 3 of ¾ in. shivers; 4 bars ⅜ in. iron 5 ties 3-16 in. iron	64	375	2·06	2·860	3·192	1680	IV. c 7	Shattered near one end, other end sound for 12 inches. Concrete off rods. Vertical rods bent.
		747	5·75	2·260	2·769			
		1120	10·96	1·330	2·310			
		1493	24·09	·420	1·436			
Mixture ditto, 4 bars ⅜ in. iron, 2 ties 3-16 in. iron	64	373	2·99	2·800	2·197	1891	IV. c 8	Ditto.
		757	6·33	2·126	2·515			
		1120	11·86	1·384	2·515			
		1493	21·89	1·310	2·125			
1 cement, 2 sand, 2 ¾ in. shivers	192	249	·64	4·146	5·448	2396	IV. d 1	Shattered near end, leaving about 12 in. sound other end.
		498	2·54	2·800	3·820			
		871	6·17	2·500	3·530			
1 cement, 2 sand, 2 ¾ in. shivers	192	249	1·24	2·880	2·801	1618	IV. d 2	Ditto.
		747	6·89	1·500	2·311			
		1120	13·77	1·165	1·821			
		1368	21·41	·592	2·476			
1 cement, 2 sand, 3¾ in. shivers	202	373	3·54	2·800	1·050	1493	IV. d 3	Shattered one end, other end sound for about 14 inches.
		749	6·88	1·500	2·311			
		1120	15·15	1·165	1·667			
		1246	17·08	·580	2·247			
1 cement, 2 sand, 3 ¾ in. shivers	205	249	1·14a	2·390	3·048	1618	IV. e 1	Ditto.
			2·28b	1·900	1·222			
			1·54a	3·045	2·255			
			2·21b	1·830	1·572			a—load ascending b—load descending
			1·73a	2·680	2·008			
		747	7·03a	2·508	3·265			
			7·55b	1·788	2·110			
			7·53a	2·220	2·115			
		1120	12·08a	1·110	2·920			
1 cement, 3 grit with dust	208	249	1·32a	2·320	2·632	1842	IV. e 2	Broken and shattered vertically
			1·67b	2·550	2·081			
			1·59a	2·355	2·185			
			2·94b	2·100	1·182			
			2·64a	2·220	1·315			
			5·50b	1·555	·682			
			4·82a	1·788	·928			
		747	8·07a	2·506	1·973			
			8·07b	3·884	1·973			
			9·21a	1·155	1·727			
			14·32b	1·848	1·113			
			12·98a	1·872	1·227			
		1120	18·06a,b	·744	1·430			
			18·67a	1·465				
1 cement, 2 sand, 2 ¾ in. shivers, 4 ½ in. bars, 2 ties 3-16 in. dia.	159	249	1·00	2·765	3·475	2464	IV. f 1	Shattered vertically
		747	5·16	2·440	3·085			
		1493	15·48	1·322	2·235			
		1867	26·82	·870	1·636			

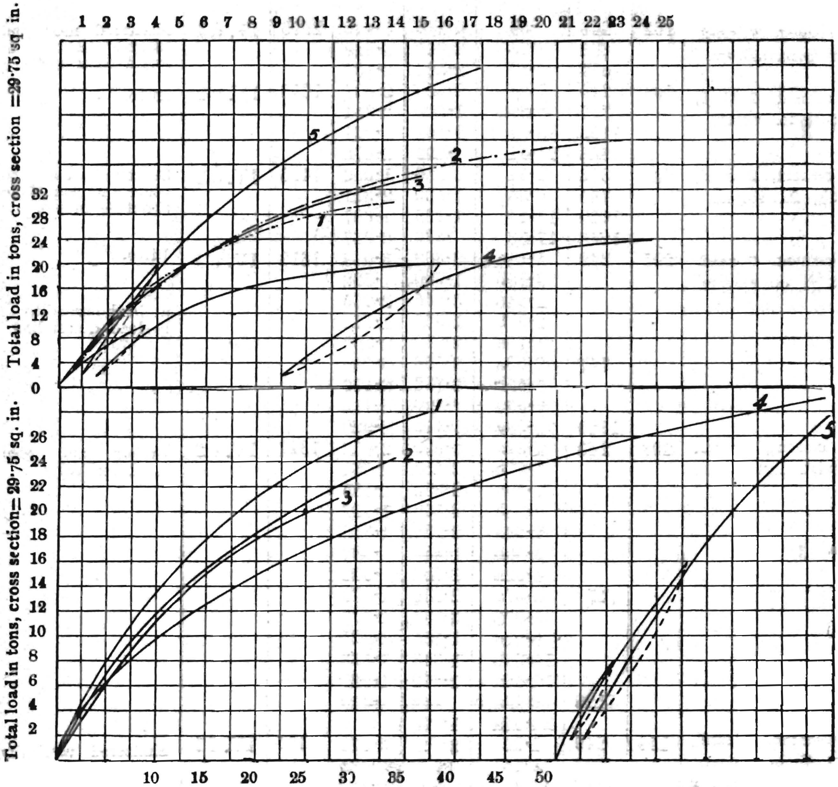
In France and America the practice is to reinforce compression members with longitudinal rods connected at intervals by perforated diaphragms or wires, and in all calculations the transverse ties are neglected, and the resistance of the longitudinal metal rods is added to the concrete.

The following experiments show the effect of reinforcing with helicoidal spiral rods embedded in the concrete near the surface, and against the inner face of these coils longitudinal rods are placed.

The following Tables XII. and XIII. give the results obtained by the author, and Figs. IVm and IVk show the results of these tests plotted.

Fig. IV. m.

Octagonal Prisms 12 inches long. Compression in units of ·0008 inches.



Compression in units of .0008 inches on 20 inches.

Fig. IV. k.

TABLE XII.—COMPRESSION TEST OF CONCRETE PRISMS.

Length 12 inches, Octagonal Section.

Elastic limit of soft steel wire used in spirals = 39,000 pounds per square inch. Elastic limit of Bessemer steel used in longitudinal rods = 37,700 pounds per square inch. Area 29 7589 square inches.

Composition.	Age in Days.	Compressive Stress, pounds per square inch	Compression in Units of .0008 inch on 20 inches	Coefficient of Elasticity in millions of pounds per square inch	E = T'al Unit Stress / T'al Unit Strain $\times 10^6$	Breaking Load in pounds per square inch	Reference to Curves	Remarks.
1 cement, 2 sand, 2 ¾ in. shivers, no bars, plain	141	301	0.80	3·760	3·740	2409	1 Fig. IV.m	Shattered; no signs of fracture before breaking
		602	1.62	3·340	3·720			
		1204	3.80	2·370	3·170			
		1806	7.25	1 250	2·490			
1 cement, 2 sand, 2 ¾ in. shivers. Spiral ¾ in. pitch 5 in. dia. No. 5 gauge wire	136	301	0·81	3·540	3 740	4220	2 Fig IV.m	Outside peeled off at 101,000 pounds and broke at 126,000 pounds; slightly crushed.
		602	1.74	3·010	3.450			
		1204	3.91	2·410	3·070			
		1806	6.96	1·740	2·580			
		2258	9·98	1·156	2·260			
		2860	19·41	·436	1·470			
1 cement, 2 sand, 2 ¾ in. shivers. Spiral ¾ in. pitch 5 in. dia. No. 5 gauge wire; 6 ½ in. steel vertical rods	135	301	0.65	4·300	4·630	4517	3 Fig IV.m	Outside peeled off at 110,000 pounds, and broke at 134,000 pounds. Crushed at centre.
		602	1·42	3·440	4·180			
		1204	3·52	2·410	3·430			
		1806	6·71	1·440	2·690			
		2258	10·73	·990	2·120			
1 cement, 2 sand, 2 ¾ in. shivers. Spiral ¾ in. pitch 5 in. dia. No. 5 gauge wire	139	a 301	0 98	2·740	3 070	3158	4 Fig IV.m	Cracked at 695,000 pounds and outside peeled off, body crushed and bent; broke at 93,000 pounds.
		602	2·49	1·600	2·420			
		b 602	3·19	4·150	1 890			
		301	2·16	2 510	1·400			
		a 301	2·09	2 870	1·440			
		602	2·15	2.280	1·910			
		1204	8·12	·765	1·480			
		b 1204	14 61	3 340	·825			
		602	12·11	1·770	·500			
		301	10·19	1·310	·296			
		a 301	9·62	2·000	·313			
		602	11·15	2·000	·545			
		1204	14·42	1·400	·836			
		1655	19·69	·450	·844			
1 cement, 2 sand, 2 ¾ in. shivers. Spiral ¾ in. pitch 5 in. dia. No. 5 gauge wire 10⅝ in. steel vertical rods.	137	a 301	0·64	5·000	4·850	5421	1 Fig. IV.m	Cracked at 134,000 pounds and outside peeled off; vertical rods bent. Prism crushed. Broke at 162,000 pounds. a—load ascending b—load descending
		602	1·41	3·760	4·280			
		b 602	1 55	6·000	3·880			
		301	0·86	4·150	3·500			
		a 301	0·83	6 000	3 630			
		602	1·52	4 150	3·950			
		1204	2·96	3·250	4·070			
		b 1204	3·50	5·470	3 440			
		602	2·20	4·300	2.740			
		301	1·39	3·540	2·160			
		a 301	1·31	4·200	2·300			
		602	2·06	4·650	2 930			
		1204	3·45	3 900	3·490			
		1806	5·03	3·000	3 590			
		2258	6 76	2·410	3·340			
		3312	12·22	1·470	2·700			
		4274	20·45	·770	2·090			

TABLE XIII.—COMPRESSION TESTS, CONCRETE PRISMS.

Length 24 inches, Octagonal Cross Section.

Elastic limit of soft steel wire used in spiral=39,000 pounds per square inch. Elastic Limit of Bessemer steel used in longitudinal rods=37,770 pounds per square inch. Area 29·75 square inch.

Composition.	Age in Days.	Compressive Stress, pounds per square inch	Compression in Units of .0008 inch on 20 inches.	Coefficient of Elasticity in millions of pounds per square inch	E = T'al Unit Stress / T'al Unit Strain $\times 10^6$	Breaking Load in pounds per square inch	Reference to Curves	Remarks
1 cement, 2 sand, 2 ¾ in. shivers, no bars.	133	301	1·80	4·180	4·180	2786	1 Fig IV.k	Crushed near one end
		602	3·35	3·425	4·550			
		1204	8 99	2 400	3 360			
		1806	16·81	1·510	2·680			
		2258	26·88	1·060	2·090			
1 cement, 2 sand, 2 ¾ in. shivers. Spiral ¾ in. pitch 5 in. dia. No. 5 gauge wire	131	301	2·03	3·760	3·700	4098	2 Fig. IV.k	Outside peeled at 90,000 ponds. Broke at 119,000 pounds. One spiral burst.
		602	4·58	2·770	3·321			
		1204	11·23	1.810	2·670			
		1806	22 21	1·140	2·040			
		2258	35·46	·942	1·580			
1 cement, 2 sand, 2 ¾ in. shivers. Spiral ¾ in. pitch 5 in. dia. No. 5 gauge wire	130	301	2·40	2·900	3·120	2846	3 Fig. IV.k	Outside peeled at 67,000 pounds, centre of prism crushed at 85,000 pounds.
		602	4·54	2·800	3·310			
		1204	11·75	1·510	2·560			
		1806	22·93	·920	1·197			
1 cement, 2 sand, 2 ¾ in. shivers. Spiral ¾ in. pitch 5 in. dia. No. 5 gauge wire 6 ½ in. dia. vertical steel rods.	129	301	1·70	3·140	4·400	5270	4 Fig IV.k	Cracked at 101,000 pounds, and outer covering peeled off at 119,000 pounds Buckled at 134,000, broke at 157,000 pounds.
		602	4·85	1·980	3·100			
		1204	15·00	1·215	2·000			
		1806	31·52	·770	1·430			
		2258	51·26	·522	1·090			
1 cement, 2 sand, 2 ¾ in. shivers. Spiral ¾ in. pitch 5 in. dia. No. 5 gauge wire 10 ⅝ in. dia vertical steel rods.	129	a { 301	2 07	3·300	3·640	4214	5 Fig. IV.k	Cracked at 112,000 pounds; the outside peeled off and broke at 126,000 pounds. Failed in body of prism. a—load ascending b—load descending
		602	4 58	2 800	3·270			
		b { 602	5·07	3·960	2·970			
		301	2·86	2·800	2·620			
		a { 301	2·46	3·420	3·050			
		602	4·88	3·000	3·080			
		1204	10·13	2·510	3·000			
		b { 1204	12·51	3·580	2·400			
		602	6·86	2·900	2·190			
		301	4·01	2 650	1·870			
		a { 301	3·68	3·140	2·040			
		602	6·09	3·140	2·470			
		1204	11·02	2·900	2·720			
		1806	16·70	3·250	2 710			
		2258	22 79	1·880	2·470			

Remarks.—On the strength of concrete prisms reinforced with longitudinal rods bound together with cross ties:—

Length of prism 24 inches.

Cross section 6 × 6 = 36 square inches.

Strength of concrete prism 1:2:2 IV. b. 1, age 84 days = 1836 lbs. per square inch.

Strength of concrete reinforced with 4 iron rods 3/8 inch diameter with cross ties of wire 3-16 inch diameter —average age 64 days = 2248 lbs. per square inch.

Difference due to reinforcement = 588 lbs. per square inch.

Area of 4 rods 3/8 inch diameter = 0.4416 square inch.

Resistance at elastic limit = 16780 lbs.

$$\text{Resistance per square inch of prism} = \frac{16780}{36} = 466 \text{ lbs.}$$

per square inch.

Hence the longitudinal rods contributed rather more than would be represented by the elastic limit of the material, the difference is probably due to the ties.

Strength of concrete prisms 1:2:3 IV. b^2 to IV. b^4, age 79 days (mean) = 1468 lbs. per square inch.

Total strength of prism reinforced with 4 iron bars 3/8 inch diameter (mean) = 2086 lbs. per square inch.

Difference due to reinforcement = 618 lbs. per square inch.

Here also the increase is greater than that of the 4 rods at their elastic limit.

The experiments on the concrete of similar composition but of different ages is shown in this table and in IV. d. 1, 2, 3, and IV. e. 1 and 2 the effects of repeated loading and unloading are shown.

The strength of the concrete prisms IV. f. 1 and 2, consisting of cement, sand, and 3/4 inch basalt shivers in the proportion of 1:2:2 having 4 rods ½ inch diameter and 2 and 5 cross ties respectively gave a mean value of 2666 lbs. per square inch. The mean resistance of two similar prisms not reinforced IV. d. 1 and 2 was 2007 lbs. per square inch, but the age was 32 days greater, the difference 659 lbs. per square inch is therefore below the amount contributed by the reinforcement. The actual resistance of the four ½ inch rods at their elastic limit is about 827 lbs. per square inch, and the cross ties must have contributed something.

The mean strength of the prisms IV. f. 2 and 3, similar in every respect to the foregoing, but with 4 rods ⅜ inch diameter, and 10 and 15 cross ties respectively, was 2619 lbs. per square inch, or a difference due to reinforcement of 612 lbs. per square inch. Here the 4 rods ⅜ inch diameter would contribute about 466 lbs. per square inch, leaving a difference of 146 lbs. per square inch to be supplied by the cross ties.

The mean strength of the reinforced prisms IV. g. 1 and 2, 182 days old was 1803 lbs. per square inch, and of similar prisms unreinforced, but 21 days older, 1555 lbs. per square inch; IV. d. 3 and IV. e. 1 giving a difference of 248 lbs. per square inch only, which is only about half as much as the actual resistance of the reinforcement.

The mean resistance of the reinforced prisms IV. g. 3 and 4. 173 days old, similar to IV. g. 1 and 2, but with 10 and 15 cross ties respectively, was 1985 lbs. per square inch, which compared with similar unreinforced prisms 30 days older shows a difference of 430 lbs. per square inch, due to the reinforcement, but although this would account for the resistance contributed by the rods, it is below what might have been expected from the rods and cross ties combined.

The prisms IV. h. 1 and 2 are reinforced with 7 grills, each consisting of 8 bars 3-16 inch in diameter arranged transversely. These prisms gave a mean strength of 2398 lbs. per square inch at 106 days, or an excess of 391 lbs. per square inch over similar prisms not reinforced but 192 days old, so that the value of this kind of reinforcement appears to be not as good as the longitudinal rods and cross ties of the same volume.

Concrete reinforced by longitudinal rods.—Tables IV. m. and IV. k. and Figs. IV. m. and IV. k. give the results of testing concrete prisms octagonal in cross section, having an area of 29.75 square inches. The lengths of these prisms were 24 and 12 inches respectively. The object of these tests was to ascertain the effect of reinforcing with soft wire spirals with and without longitudinal rods of steel.

M. Considere has pointed out that when concrete prisms reinforced with longitudinal rods are allowed to set in water the rods are extended, due to the swelling of the concrete, and when allowed to set in air they are compressed.

The expression

$$p_s = E_s \lambda_s$$

is true only when λ_s includes the initial strain due to shrinkage as well as that due to the applied load. The initial stress upon the longitudinal rods in a concrete prism set in air may be very near the intensity of stress at the elastic limit of the metal, and thus the rods begin to deform plastically with very moderate intensities of stress and contribute very little to the strength of the prism. The strength in any case cannot differ much from that due to the sum of the resistances of the concrete to crushing, and to the resistance of the rods up to the elastic limit of the metal.

If A = the area of cross section of prism.
a = the area of rods.
c = the compressive strength of the concrete.

w = the total load carried.

Then,

$$w = c\left(A + \frac{E^s}{E^c}a\right)$$

In IV. m. 1, the shortening of the prism per inch with a stress of 1806 lbs. per square inch was 0.000725 inch, corresponding with a stress of 21750 lbs. per square inch. If we add to this stress, the initial stress due to shrinkage, say 7,000lbs. square inch, we have 28750 lbs. per square inch as the total intensity of stress on the rods when the prism is under a stress of 1806 lbs. per square inch. At 2409 lbs. per square inch, when the prism fractured, the stress on the rods would be much greater, so that there is very small margin remaining which is available in the case of a reinforced prism.

Concrete reinforced with transverse rods or grills.—The tendency to shear along oblique planes is resisted by rods whether they are arranged parallel with or at right angles to the direction of pressure, in consequence of the equality of the intensities of shearing stresses on planes at right angles to each other, so that transverse rods behave in a manner very similar to longitudinal rods.

Concrete prisms reinforced by means of spirals of soft iron or steel wire.—M. Considere has shown that a prism of sand reinforced by a continuous shell offers 2·4 times the resistance of the sand when reinforced by longitudinal rods of the same weight as the shell, and he infers that spirals or hoops are 2·4 times as effective as the same weight of metal arranged as longitudinal rods in a concrete prism. The spirals are in tension from the swelling of the concrete which is much smaller than the longitudinal shortening of the rods, and concrete reinforced by spirals can sustain great deformations without injury to either metal or concrete. The compressive resistance of a concrete prism reinforced with spirals and longitudinal rods is the sum of the resistances due to:—

1. The compressive resistance of the plain concrete without reinforcement.
2. The compressive resistance of the longitudinal rods up to their elastic limit.
3. The compressive resistance which would have been produced by imaginary longitudinal rods at the elastic limit of the material used in the spirals, the volume of the imaginary rods being 2·4 times that of the spiral.

Remarks.—On the compressive strength of reinforced concrete prisms, octagonal in cross section:—

Area 29·75 square inches, Fig. IV. m., length = 12 inches.

No. 1. Compressive strength of concrete, prism not reinforced = 2409 lbs. per square inch.

No. 2. Reinforced with a spiral 5 inch in diameter of wire 0·2 inch in diameter = 4220 lbs. per square inch.

Increase due to spiral = 1811 lbs. per square inch.

Ratio of area of metal to concrete = ·022

$$\cdot 022 \times 39000 = 858 \text{ lbs. per square inch.}$$

$$\text{Ratio } \frac{1811}{858} = 2 \cdot 1$$

The efficiency of the spiral over an equal volume of metal arranged as longitudinal rods = 2·1 times as great.

No. 3. Total compressive strength = 4517 lbs. per sq. in.
Resistance of spiral from last test = 1811 „ „
Resistance of concrete .. .. = 2409 „ „
Increase in strength due to 6 Bessemer steel rods ½ inch in diameter = 297 lbs. per square inch.

Area of rods = 6 × 0·196
= 1·176.
Limit of elasticity of metal = 37770 lbs. per sq. inch.
Resistance of the rods if unstrained before testing =

$$\frac{1 \cdot 175 \times 37770}{29 \cdot 5} = 1490 \text{ lbs. per square inch.}$$

Hence these rods did not contribute their full resistance in consequence of the initial compression due to shrinkage of the concrete.

No. 4. The total strength of concrete prism reinforced = 3158 lbs. per square inch.

Increase due to spiral = 749 lbs. per square inch.

Here the ratio $\frac{749}{858} = 0 \cdot 87$. Whereas a similar test, No. 2, gave a ratio of 2·1.

No. 5. The total strength of the reinforced prism = 5421 lbs. per square inch.

Increase due to reinforcement = 3012 lbs. per square inch.

Assuming that the spiral contributed 1811 lbs. as in No. 2, the increase due to rods = 1201 lbs. per square inch.

10 Bessemer steel rods 3/8 inch diameter having an elastic limit of 37770 lbs. per square inch =

$$\frac{1 \cdot 104 \times 37770}{29 \cdot 75} = 1400 \text{ lbs. per square inch.}$$

In this case the rods appear to have contributed nearly their full amount, assuming the spirals contributed the same amount as in No. 2 tests.

Concrete prisms 24 inches long, Fig. IV. k.

No. 1. Compressive strength of concrete prism, not reinforced = 2786 lbs. per square inch.

No. 2. Reinforced with spiral 5 inch diameter of wire