Concrete mix design data

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Second edition

CEMENT AND CONCRETE ASSOCIATION

This collection of data is reproduced from *Concrete Mix Design*, by the same author, and is published separately for the convenience of those who may need to use them frequently. It contains only those Figures and Tables which are used regularly in mix design calculations; to facilitate interpolation, some of the Figures are reproduced to a larger scale than that used in the book.

Reference should be made to the book for guidance on the methods of using and interpreting the data.

This booklet is divided into three sections: data applicable to mix design generally and data for the methods appropriate to the design of medium-strength and of high-strength concrete mixes (Chapters 4 and 6, respectively).

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GENERAL DATA

TABLE 1: Standard mixes[1]

Weights of dry fine and coarse aggregates per 112 lb of cement based on aggregates having a specific gravity of 2·6 and a natural sand having a grading within the limits of grading zone 2 in B.S. 882.

If a crushed stone sand or a crushed gravel sand is used instead of a natural sand, the weight of coarse aggregate should be reduced by at least 25 lb.

If the grading of the fine aggregate is within the limits of grading zone 3 of B.S. 882 the weight of fine aggregate should be decreased by at least 25 lb, or if within grading zone 1 increased by at least 25 lb; the weight of coarse aggregate should be increased or decreased, respectively, by the same amount so that the total weight of aggregate remains the same. Adjustments larger than 25 lb are more likely to be required with the leaner mixes.

If the specific gravity of either the coarse or the fine aggregate differs sufficiently from 2·6 to alter the weight of the absolute volume of the material in the batch by more than 15 lb, the weight of each type of aggregate should be adjusted in proportion to the specific gravity of the aggregate.

Standard deviation[2] (*lb/in²*)	*Specified minimum strength at* 7/28 days (*lb/in²*)	*Weight of dry sand* (*lb*)	*Weight of dry gravel or crushed rock coarse aggregate*[3] (lb)											
			⅜ *in. maximum size*			½ *in. maximum size*			¾ *in. maximum size*			1½ *in. maximum size*		
	Workability[4]		*Low*	*Medium*	*High*	*Low*	*Medium*	*High*	*Low*	*Medium*	*High*	*Low*	*Medium*	*High*
	Slump (in.)		0–¼	¼–1	1–2	¼–¾	¾–1½	1½–4	½–1	1–2	2–5	1–2	2–4	4–7
	Compacting factor		0·80–0·86	0·86–0·92	0·92–0·97	0·81–0·87	0·87–0·93	0·93–0·97	0·82–0·88	0·88–0·94	0·94–0·97	0·82–0·88	0·88–0·94	0·94–0·97
500	2,000/3,000	300	350	275	225	400	325	275	450	375	325	(5)	(5)	425
	2,500/3,750	250	350	275	225	400	325	275	450	375	325	(5)	450	400
	3,000/4,500	200	325	250	200	375	300	250	425	350	300	500	425	375
1,000	2,000/3,000	200	325	250	200	375	300	250	425	350	300	500	425	375
	2,500/3,750	175	275	200	150	325	250	200	375	300	250	450	375	325
	3,000/4,500	150	225	(5)	(5)	275	200	(5)	325	250	200	375	300	250

NOTES 1. *Standard mixes apply only to concrete made with cement complying with B.S.* 12 *or B.S.* 146 *and with aggregates complying with B.S.* 882 *or B.S.* 1047. *Fine aggregates in grading zone* 4 *of B.S.* 882 *and air-entraining agents should not be used with standard mixes.*

2. *Interpolation is permissible, the weights of each aggregate fraction being rounded off to the nearest* 25 *lb lower.*

3. *Single-sized course aggregates should be used in proportions which will produce combined gradings within the limits of B.S.* 882 *or B.S.* 1047 *for graded aggregate of the appropriate size.*

4. *Interpolation is permissible, the weight of coarse aggregate being rounded off to the nearest* 25 *lb lower.*

5. *These mixes would have cement contents outside the limits of* 500 *and* 900 *lb of cement per yd³ of concrete.*

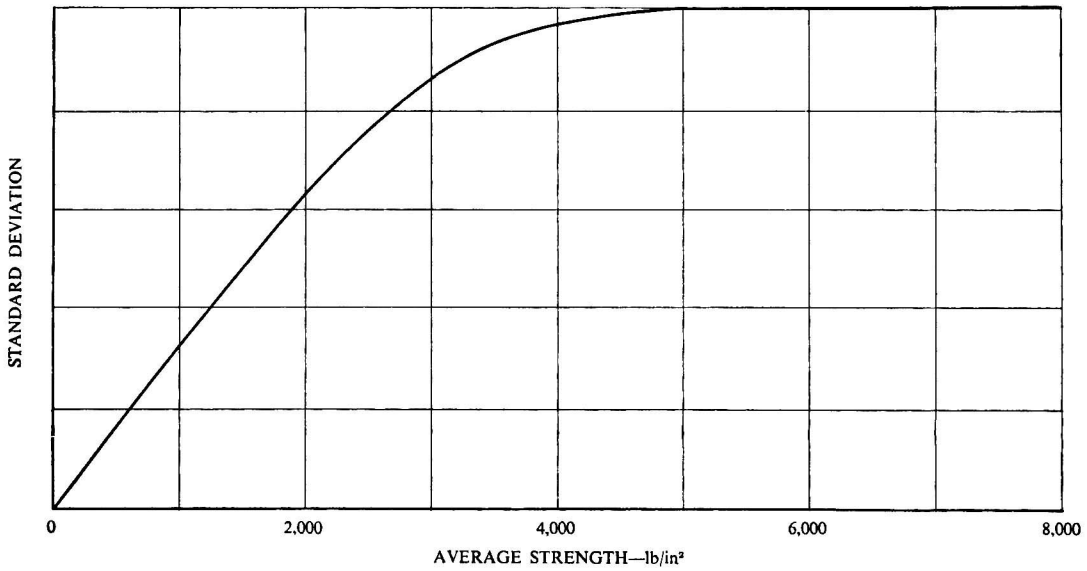

Figure 2: Relation between standard deviation and average compressive strength of concrete for different degrees of control. The vertical scale depends on the degree of control; the upper value ranges from 520 to 1,100 lb/in² as indicated in Table 2.

TABLE 2: Values of standard deviation and control ratio for different standards of quality control.

Batching		*Supervision*	*Standard deviation for average strength above 5,000 lb/in²* (*lb/in²*)	*Control ratio for 1 result in 44 below the minimum*
Cement	*Aggregate*			
Weight (servo-operation)	Weight (servo-operation)	Poor	810	0·78
		Normal	670	0·82
		Good	520	0·86
Weight	Weight	Poor	930	0·75
		Normal	780	0·79
		Good	630	0·83
Weight	Volume	Poor	1,030	0·72
		Normal	860	0·77
		Good	670	0·82
Volume	Volume	Poor	1,100	0·70
		Normal	930	0·75
		Good	750	0·80

NOTES: *For the special method of quality control referred to in CP* 115 (1959) *and CP* 2007 (1960) *the standard deviation should not be likely to exceed* 750 *lb/in². This corresponds to a minimum control ratio of* 0·80 *where the average strength is above* 5,000 *lb/in².*

For the calculation of the control ratio appropriate to other proportions of results expected below the minimum see Section 4.2.1.

TABLE 3: Types of high-strength mixes within the scope of Chapter 6 for different average strengths at 28 days using $\frac{3}{4}$ in. aggregate.

Average strength at 28 days (lb/in^2)	*Workability of mix*			
	O.P.C.		*R.H.P.C.*	
	Gravel	*Granite*	*Gravel*	*Granite*
5,000	*M*	—	—	—
6,000	*L, M*	*L, M*	*M*	—
7,000	*VL, L, (M)*	*L, M*	*VL, L, M*	*L, M*
8,000	*VL*	*VL, L, (M)*	*VL, (L)*	*VL, L, M*
9,000	—	*VL, (L)*	*EL–VL*	*VL, L*
10,000	—	*EL–VL*	—	*EL–VL*
11,000	—	—	—	*EL*

NOTES: *M* = "*Medium*", *L* = "*Low*", *VL* = "*Very Low*", *EL* = "*Extremely Low*" (*see Table* 6).

Workabilities given in ( ) would require mixes with more than 900 lb of cement per yd³ of concrete.

TABLE 5: Strength of concrete and minimum nominal concrete cover to all steel necessary to meet durability requirements.

Conditions of exposure	*Minimum*[1] *nominal*[2] *concrete cover (in.)*				
	Specified works cube strength at 7/28 days (lb/in²)				
	2,000/3,000	2,500/3,750	3,000/4,500	4,250/6,000	5,500/7,500
INTERNAL					
Non-corrosive	¾	½	½	½	½
Corrosive: e.g. roof units subject to condensation	1	¾	½	½	½
Severely corrosive: e.g. roof units subject to corrosive fumes	N.A.[3]	1½	1	1	1
EXTERNAL					
Sheltered[4] in non-industrial areas: e.g. in occupied buildings surrounded by other buildings	1	1	1	¾	¾
Sheltered in industrial areas or work against non-sulphate-bearing earth faces	1½	1	1	1	¾
Exposed[5] in non-industrial areas: e.g. open farm buildings	N.A.	1½	1	1	1
Exposed in industrial areas or subject to mild sulphate attack	N.A.	N.A.	1½	1	1
Exposed to sea-water or weak chemical attack	N.A.	N.A.	N.A.	2	2
Subject to salt used for de-icing: e.g. roadside structures	N.A.	N.A.	1½[6]	1[6]	1[6]

NOTES: 1. *For internal work under corrosive conditions, for external work and for work against earth faces, the values of cover given in the Table may be reduced when the face of the concrete is adequately protected by a suitable cladding or protective coating. However, the values may have to be increased for special conditions, as follows:*
(i) *not less than ¼ in. greater than the nominal maximum size of the aggregate if porous aggregates are used;*
(ii) *not less than 1 in. where calcium chloride is used in the concrete unless permanent protection is provided;*
(iii) *½ in. greater than the values given in the Table for lightweight aggregate concrete, except for internal non-corrosive conditions;*
(iv) *not less than 1 in. for lightweight aggregate concrete with a specified works cube strength at 28 days of less than 3,000 lb/in² used in internal non-corrosive conditions;*
(v) *where necessary to allow for any subsequent surface treatment.*

2. *The minimum nominal concrete cover given in the Table applies to all steel including stirrups and links, and in practice the steel should be positioned so that the actual concrete cover is nowhere smaller than the required nominal cover by more than ⅛ in.*
3. *N.A. indicates that this grade of concrete is not allowed under the particular conditions of exposure.*
4. *Not subject to the freezing of damp concrete.*
5. *Subject to alternate wetting and drying with fresh or rain water and to freezing.*
6. *Applicable only to air-entrained concrete. Suggested air contents for concrete made with aggregate of: ⅜ in. maximum size, 6–8%; ¾ in. maximum size, 4–6%; 1½ in. maximum size, 3–5%. The air content should be controlled within ±1% of the average.*

TABLE 6 : Selected values of compacting factor and slump for different conditions of placing.

Placing conditions	*Degree of workability*	*Nominal maximum size of aggregate (in.)*	*Compacting factor*	*Slump (in.)*
Sections subject to extremely intensive or prolonged vibration or to vibration accompanied by pressure	"Extremely Low"	$\frac{3}{8}$ $\frac{3}{4}$	0·65 0·68	0 0
Small sections subject to intensive vibration, large sections with normal vibration	"Very Low"	$\frac{3}{8}$ $\frac{3}{4}$ $1\frac{1}{2}$	0·75 0·78 0·78	0 0–$\frac{1}{2}$ 0–1
Simply reinforced sections with vibration, large sections without vibration	"Low"	$\frac{3}{8}$ $\frac{3}{4}$ $1\frac{1}{2}$	0·83 0·85 0·85	0–$\frac{1}{4}$ $\frac{1}{2}$–1 1–2
Simply reinforced sections without vibration, heavily reinforced sections with vibration	"Medium"	$\frac{3}{8}$ $\frac{3}{4}$ $1\frac{1}{2}$	0·90 0·92 0·92	$\frac{1}{4}$–1 1–2 2–4
Heavily reinforced sections without vibration. Not normally suitable for vibration	"High"	$\frac{3}{8}$ $\frac{3}{4}$ $1\frac{1}{2}$	0·95 0·95 0·95	1–4 2–5 4–7

MEDIUM-STRENGTH DESIGN DATA
(Chapter 4)

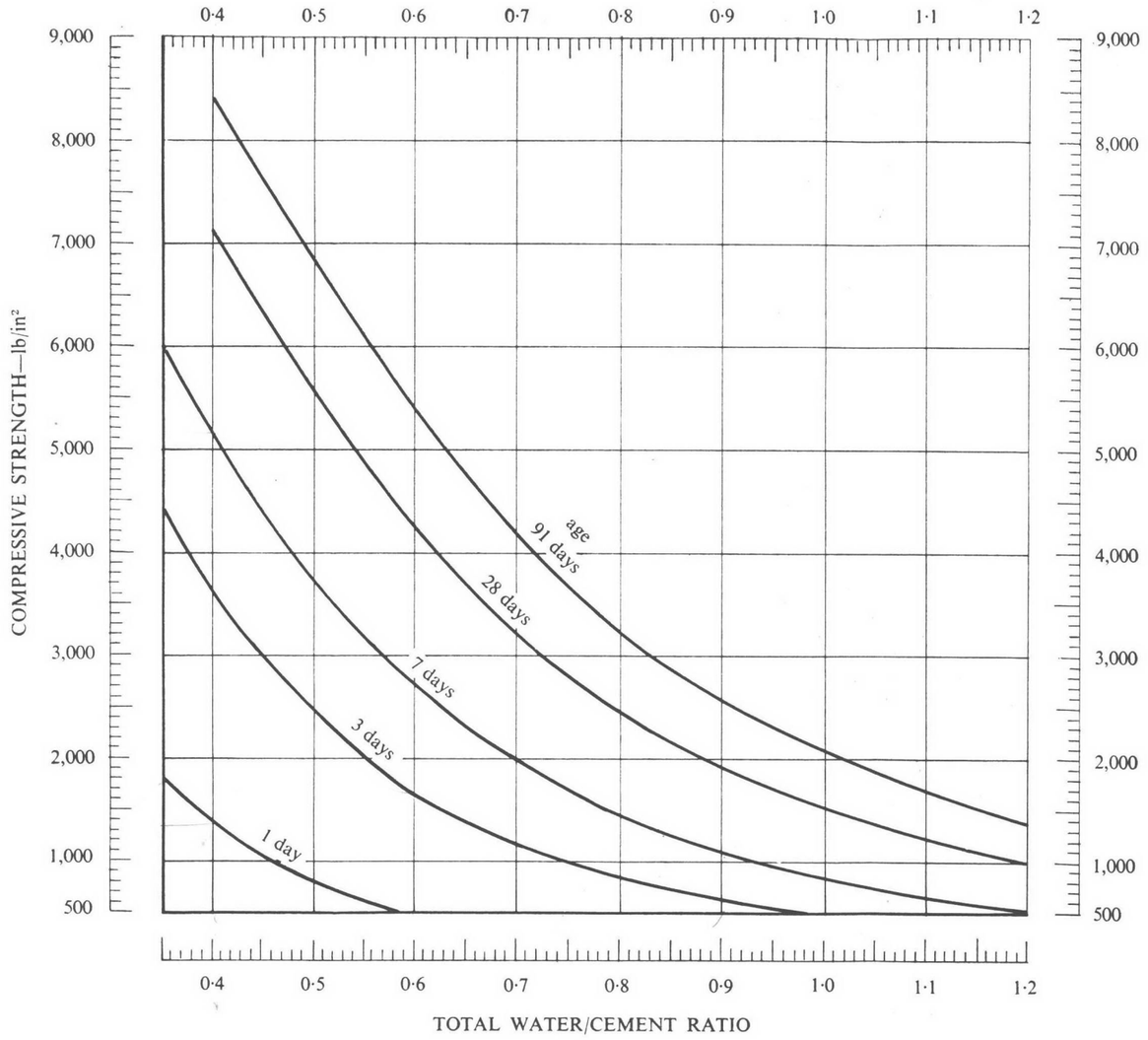

Figure 4: Relation between compressive strength of medium strength concrete and total water/cement ratio at various ages using ordinary Portland cement.

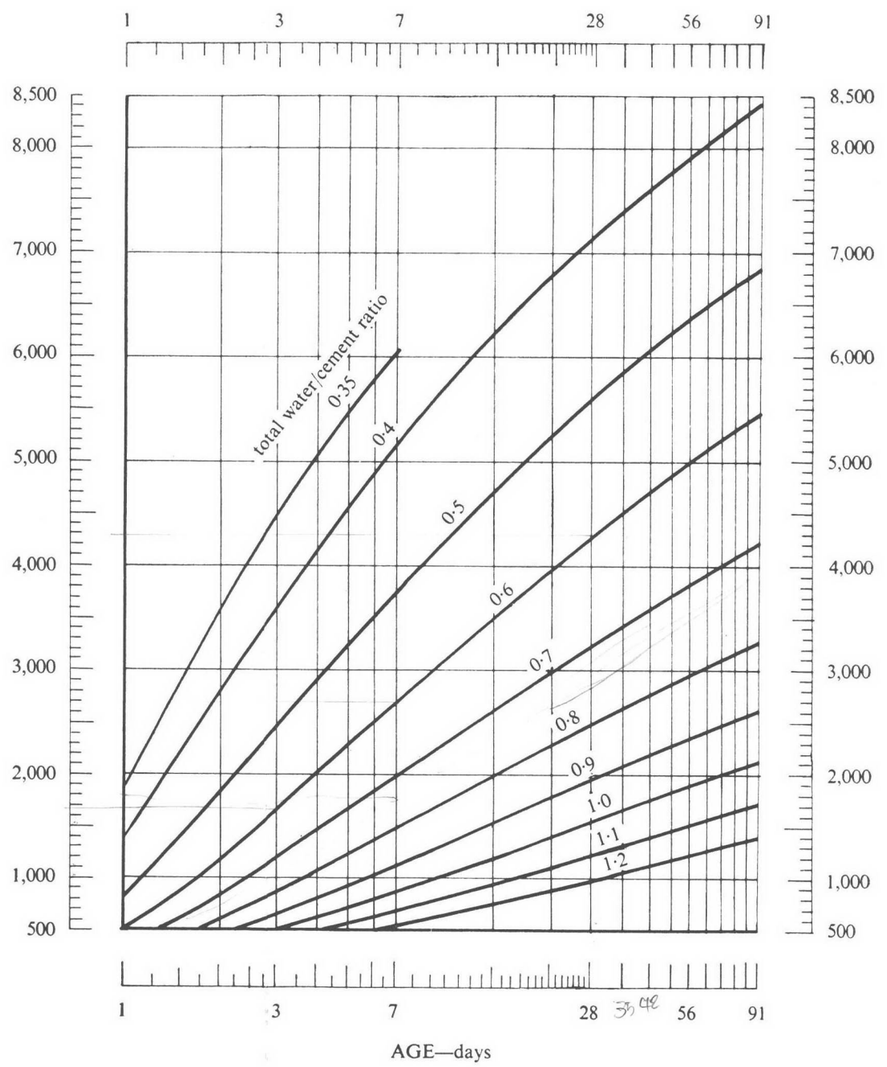

Figure 5: Relation between compressive strength of medium strength concrete and age for various water/cement ratios using ordinary Portland cement.

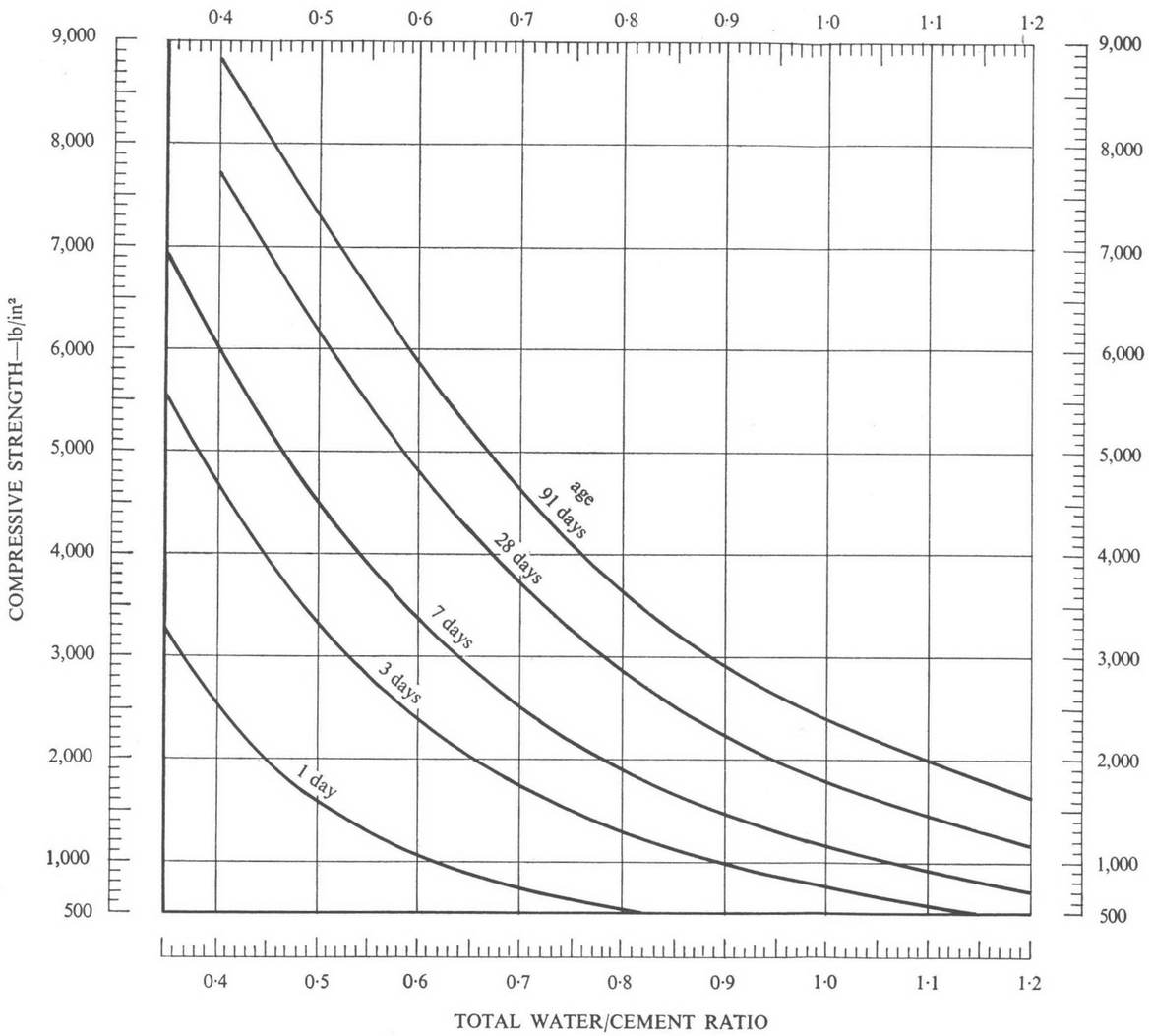

Figure 6: Relation between compressive strength of medium strength concrete and total water/cement ratio at various ages using rapid-hardening Portland cement.

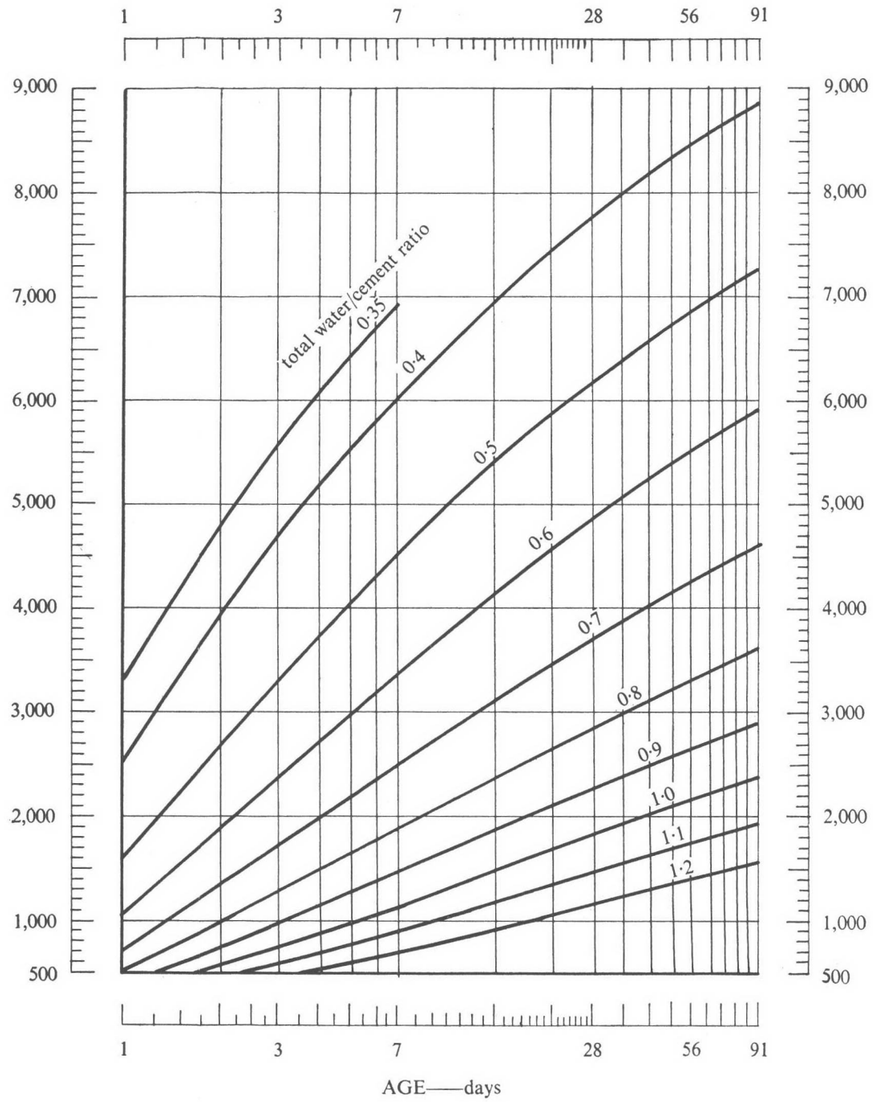

Figure 7: Relation between compressive strength of medium strength concrete and age for various water/cement ratios using rapid-hardening Portland cement.

W/C V. STRENGTH (R.H.P.C.)

TABLE 7: Aggregate/cement ratio required to give four degrees of workability with different water/cement ratios and gradings

⅜ IN. ROUNDED GRAVEL AGGREGATE

		Aggregate/cement ratio by weight															
Degree of workability (Table 6)		*"Very Low"*				*"Low"*				*"Medium"*				*"High"*			
Grading number (Figure 12)		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Total water/cement ratio by weight	0·40	5·6	5·0	4·2	3·2	4·5	3·9	3·3	2·6	3·9	3·5	3·0	2·4	3·5	3·2	2·8	2·3
	0·45	7·2	6·4	5·3	4·1	5·5	4·9	4·1	3·2	4·7	4·3	3·7	3·0	4·2	3·9	3·4	2·9
	0·50		7·8	6·4	4·9	6·5	5·8	4·9	3·8	5·4	5·0	4·3	3·5	4·8	4·5	4·0	3·4
	0·55			7·5	5·7	7·4	6·7	5·7	4·4	6·1	5·7	4·9	4·0	5·3	5·1	4·5	3·9
	0·60				6·5		7·5	6·4	5·0	6·7	6·3	5·5	4·5	5·8	5·6	5·0	4·3
	0·65				7·2			7·1	5·6	7·3	6·9	6·1	5·0	S	6·1	5·5	4·7
	0·70							7·7	6·2	7·9	7·5	6·7	5·5		6·6	6·0	5·1
	0·75								6·7			7·2	5·9		7·1	6·5	5·5
	0·80								7·2			7·7	6·3		7·6	6·9	5·9
	0·85												6·8			7·3	6·3
	0·90												7·2			7·7	6·7
	0·95																7·0
	1·00																7·3

S *Indicates that the mix would segregate.*

TABLE 8: Aggregate/cement ratio required to give four degrees of workability with different water/cement ratios and gradings

$\frac{3}{8}$ IN. IRREGULAR GRAVEL AGGREGATE

		Aggregate/cement ratio by weight															
Degree of workability (Table 6)		*"Very Low"*				*"Low"*				*"Medium"*				*"High"*			
Grading number (Figure 12)		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Total water/cement ratio by weight	0·40	4·1	3·8	3·3	2·8	3·3	3·1	2·8	2·3								
	0·45	5·1	4·8	4·3	3·6	4·1	3·9	3·5	3·0	3·5	3·4	3·2	2·8	3·2	3·1	3·0	2·7
	0·50	6·1	5·8	5·2	4·4	4·8	4·6	4·2	3·7	4·2	4·1	3·8	3·4	S	3·8	3·6	3·2
	0·55	7·0	6·7	6·1	5·2	5·5	5·3	4·9	4·3	S	4·7	4·4	4·0		4·4	4·2	3·7
	0·60	7·9	7·6	7·0	6·0	S	6·0	5·6	4·9		5·3	5·0	4·5		4·9	4·7	4·2
	0·65			7·8	6·8		6·6	6·2	5·5		5·9	5·6	5·0		5·4	5·2	4·6
	0·70						7·2	6·8	6·1		6·4	6·1	5·5		5·9	5·7	5·0
	0·75						7·8	7·4	6·7		6·9	6·6	6·0		6·4	6·1	5·4
	0·80							8·0	7·3		7·4	7·1	6·4		6·8	6·5	5·8
	0·85										7·9	7·5	6·8		7·2	6·9	6·2
	0·90											8·0	7·2		7·6	7·3	6·6
	0·95														S	7·7	6·9
	1·00															8·0	7·2

S *Indicates that the mix would segregate.*

TABLE 9: Aggregate/cement ratio required to give four degrees of workability with different water/cement ratios and gradings

$\frac{3}{8}$ IN. CRUSHED ROCK AGGREGATE*

		Aggregate/cement ratio by weight															
Degree of workability (Table 6)		*"Very Low"*				*"Low"*				*"Medium"*				*"High"*			
Grading number (Figure 12)		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Total water/cement ratio by weight	0·40	3·7	3·3	2·8	2·0												
	0·45	4·5	4·1	3·5	2·6	3·8	3·6	3·0	2·2	3·3	3·1	2·7	2·1				
	0·50	5·2	4·9	4·2	3·2	4·4	4·2	3·6	2·7	3·8	3·7	3·2	2·6	S	3·2	2·9	2·4
	0·55	5·9	5·6	4·9	3·8	4·9	4·8	4·2	3·2	S	4·2	3·7	3·0		3·7	3·4	2·8
	0·60	6·6	6·3	5·5	4·3	S	5·3	4·7	3·7		4·7	4·2	3·4		4·2	3·8	3·2
	0·65	7·3	7·0	6·1	4·8		5·8	5·2	4·2		5·1	4·6	3·8		4·6	4·2	3·6
	0·70	7·9	7·6	6·7	5·3		6·3	5·7	4·6		5·6	5·1	4·2		5·0	4·6	4·0
	0·75			7·3	5·8		6·8	6·2	5·0		6·0	5·5	4·6		5·4	5·0	4·4
	0·80			7·8	6·3		7·2	6·6	5·5		6·4	5·9	5·0		5·8	5·4	4·7
	0·85				6·8		7·6	7·1	6·0		6·7	6·3	5·4		6·1	5·8	5·1
	0·90				7·3			7·5	6·4		7·1	6·7	5·8		6·4	6·1	5·4
	0·95							7·9	6·8		7·5	7·1	6·1		6·7	6·4	5·7
	1·00								7·2		7·8	7·5	6·5		7·0	6·7	6·1
	1·05											7·8	6·9		7·3	7·0	6·4
	1·10												7·2		7·6	7·3	6·7
	1·15														S	7·6	7·0
	1·20															7·9	7·3

* *With crushed aggregate of poorer shape than that tested, segregation may occur at a lower aggregate/cement ratio.*

S *Indicates that the mix would segregate.*

TABLE 10: Aggregate/cement ratio required to give four degrees of workability with different water/cement ratios and gradings

$\frac{3}{4}$ IN. ROUNDED GRAVEL AGGREGATE

		Aggregate/cement ratio by weight															
Degree of workability (*Table* 6)		*"Very Low"*				*"Low"*				*"Medium"*				*"High"*			
Grading number (*Figure* 13)		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Total water/cement ratio by weight	0·35	4·5	4·2	3·7	3·2	3·8	3·6	3·3	3·0	3·1	3·0	2·8	2·6				
	0·40	6·6	6·1	5·4	4·5	5·3	5·1	4·6	4·1	4·2	4·2	3·9	3·6	3·7	3·8	3·6	3·3
	0·45	8·1	7·6	6·7	5·8	6·9	6·6	5·9	5·1	5·3	5·3	5·0	4·6	4·6	4·8	4·5	4·1
	0·50			8·0	7·0	8·2	8·0	7·0	6·0	6·3	6·3	6·0	5·5	5·5	5·7	5·4	4·8
	0·55				8·1			8·2	6·9	7·3	7·3	7·0	6·3	6·3	6·5	6·1	5·5
	0·60								7·7			8·0	7·1	S	7·2	6·8	6·1
	0·65								8·4				7·8		7·7	7·4	6·6
	0·70															7·9	7·1
	0·75																7·6

S *Indicates that the mix would segregate.*

TABLE 11: Aggregate/cement ratio required to give four degrees of workability with different water/cement ratios and gradings

¾ IN. IRREGULAR GRAVEL AGGREGATE

		Aggregate/cement ratio by weight															
Degree of workability (Table 6)		*"Very Low"*				*"Low"*				*"Medium"*				*"High"*			
Grading number (Figure 13)		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Total water/cement ratio by weight	0·35	3·6	3·6	3·5	3·0	3·0	3·0	3·0	2·7								
	0·40	4·9	4·8	4·6	4·1	3·9	3·9	3·9	3·5	3·3	3·4	3·4	3·2	3·1	3·2	3·2	2·9
	0·45	6·0	5·8	5·5	5·0	4·8	4·8	4·7	4·3	4·0	4·1	4·1	3·9	S	3·8	3·8	3·5
	0·50	7·2	6·8	6·4	5·9	5·5	5·5	5·4	5·0	4·6	4·8	4·8	4·5		4·4	4·4	4·1
	0·55	8·3	7·8	7·3	6·7	6·2	6·2	6·1	5·7	S	5·4	5·3	5·1		4·9	4·9	4·7
	0·60	9·4	8·7	8·1	7·4	6·9	6·9	6·7	6·3		6·0	5·9	5·6		S	5·4	5·2
	0·65				8·0	7·5	7·5	7·3	6·8		S	6·4	6·1			5·8	5·7
	0·70					8·0	8·0	7·8	7·3			6·8	6·6			6·2	6·1
	0·75								7·9			7·2	7·0			6·6	6·5
	0·80											7·5	7·4			S	7·0
	0·85											7·8	7·8				7·4
	0·90											S	8·1				7·7
	0·95																8·0
	1·00																S

S *Indicates that the mix would segregate.*

TABLE 12: Aggregate/cement ratio required to give four degrees of workability with different water/cement ratios and gradings

¾ IN. CRUSHED ROCK AGGREGATE

		Aggregate/cement ratio by weight															
Degree of workability (*Table* 6)		*"Very Low"*				*"Low"*				*"Medium"*				*"High"*			
Grading number (*Figure* 13)		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Total water/cement ratio by weight	0·40	4·5	4·1	3·8	3·5	3·5	3·5	3·2	3·0								
	0·45	5·5	5·0	4·6	4·3	4·3	4·2	3·9	3·7	3·7	3·7	3·4	3·3	3·5	3·5	3·2	3·1
	0·50	6·5	5·9	5·4	5·0	5·0	4·9	4·5	4·3	4·2	4·2	3·9	3·8	S	3·9	3·8	3·5
	0·55	7·2	6·6	6·0	5·7	5·7	5·5	5·0	4·8	4·7	4·7	4·5	4·3		S	4·3	4·0
	0·60	7·8	7·2	6·6	6·3	6·3	6·0	5·6	5·3	S	5·2	4·9	4·8			4·7	4·5
	0·65	8·3	7·7	7·2	6·9	6·9	6·5	6·1	5·8		5·7	5·4	5·2			5·2	4·9
	0·70	8·7	8·2	7·7	7·5	7·4	7·0	6·6	6·3		6·2	5·8	5·7			5·5	5·3
	0·75			8·2	8·0	7·9	7·5	7·0	6·7		S	6·2	6·1			5·8	5·7
	0·80							7·4	7·2			6·6	6·5			6·1	6·0
	0·85							7·8	7·6			7·1	6·9			6·4	6·3
	0·90											7·5	7·3			S	6·7
	0·95											8·0	7·6				7·0
	1·00																7·3

S *Indicates that the mix would segregate.*

TABLE 13: Aggregate/cement ratio required to give four degrees of workability with different water/cement ratios and gradings

$1\frac{1}{2}$ IN. ROUNDED GRAVEL AGGREGATE

		Aggregate/cement ratio by weight															
Degree of workability (*Table* 6)		*"Very Low"*				*"Low"*				*"Medium"*				*"High"*			
Grading number (*Figure* 14)		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Total water/cement ratio by weight	0·35	5·0	4·5	3·9	3·4	4·3	3·9	3·5	3·1	3·4	3·1	2·9	2·7				
	0·40	7·0	6·5	5·7	4·9	5·9	5·6	5·0	4·4	4·7	4·6	4·3	3·8	4·1	4·0	3·9	3·5
	0·45	8·9	8·6	7·7	6·5	7·6	7·4	6·7	5·8	6·0	6·1	5·7	5·0	5·2	5·3	5·0	4·6
	0·50				8·0			8·2	7·2	7·5	7·6	7·1	6·3	6·3	6·5	6·2	5·7
	0·55								8·4		8·9	8·1	7·3	S	7·7	7·4	6·7
	0·60																7·6

S *Indicates that the mix would segregate.*

NOTE: *These values have been obtained by extrapolation of other data and are not based directly on the results of trial mixes.*

TABLE 14: Aggregate/cement ratio required to give four degrees of workability with different water/cement ratios and gradings

$1\frac{1}{2}$ IN. IRREGULAR GRAVEL AGGREGATE

		Aggregate/cement ratio by weight															
Degree of workability (*Table* 6)		*"Very Low"*				*"Low"*				*"Medium"*				*"High"*			
Grading number (*Figure* 14)		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Total water/cement ratio by weight	0·35	4·0	3·9	3·6	3·2	3·4	3·3	3·2	2·9								
	0·40	5·3	5·2	4·8	4·3	4·5	4·5	4·2	3·8	3·8	3·8	3·7	3·4	3·4	3·5	3·3	3·1
	0·45	6·6	6·5	6·0	5·3	5·6	5·6	5·3	4·8	4·6	4·7	4·6	4·3	4·1	4·4	4·3	4·0
	0·50	7·8	7·7	7·1	6·3	6·6	6·6	6·3	5·7	5·5	5·7	5·5	5·1	4·8	5·2	5·1	4·8
	0·55			8·1	7·3	7·6	7·6	7·2	6·6	6·2	6·5	6·3	5·9	S	5·9	5·9	5·5
	0·60								7·4	7·0	7·3	7·1	6·6		S	6·7	6·3
	0·65								8·1	7·8	8·1	7·8	7·3			7·3	6·9
	0·70												7·9				7·4
	0·75																8·0

S *Indicates that the mix would segregate.*

TABLE 15: Aggregate/cement ratio required to give four degrees of workability with different water/cement ratios and gradings

$1\frac{1}{2}$ IN. CRUSHED ROCK AGGREGATE

		Aggregate/cement ratio by weight															
Degree of workability (Table 6)		*"Very Low"*				*"Low"*				*"Medium"*				*"High"*			
Grading number (Figure 14)		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Total water/cement ratio by weight	0·35	3·4	3·4	3·2	2·9												
	0·40	4·9	4·6	4·2	3·8	4·0	3·8	3·6	3·3	3·3	3·3	3·2	3·0	3·1	3·1	2·9	2·7
	0·45	6·0	5·7	5·2	4·7	4·9	4·7	4·4	4·2	4·1	4·1	3·9	3·8	3·7	3·8	3·7	3·4
	0·50	7·2	6·8	6·2	5·6	5·8	5·6	5·3	5·0	4·8	4·8	4·7	4·6	4·4	4·5	4·5	4·2
	0·55	8·1	7·7	7·1	6·4	6·6	6·4	6·1	5·8	5·5	5·5	5·4	5·3	S	5·2	5·2	4·8
	0·60		8·6	8·0	7·2	7·4	7·2	6·9	6·6	6·1	6·2	6·1	6·0		S	5·9	5·6
	0·65			8·8	7·9	8·1	7·9	7·6	7·3	S	6·9	6·8	6·6			6·5	6·2
	0·70				8·6		8·5	8·3	7·9		7·5	7·5	7·3			7·1	6·8
	0·75								8·5			8·1	7·8				7·4

S *Indicates that the mix would segregate.*

NOTE: *These values have been obtained by extrapolation of other data and are not based directly on the results of trial mixes.*

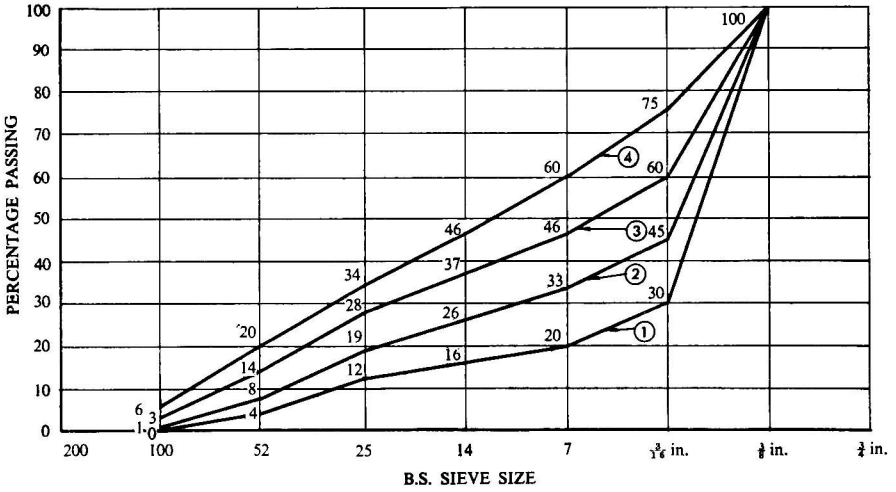

Figure 12: Grading curves for $\frac{3}{8}$ in. maximum size aggregate.

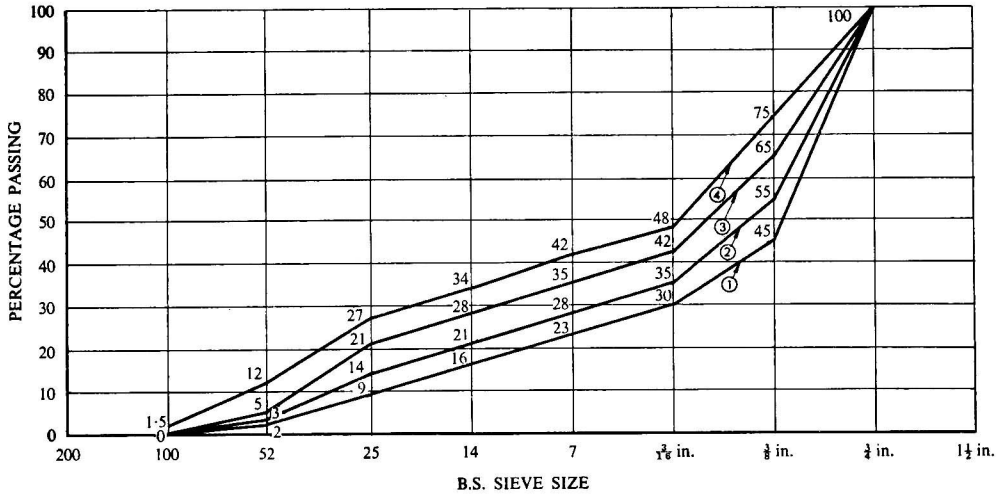

Figure 13: Grading curves for $\frac{3}{4}$ in. maximum size aggregate.

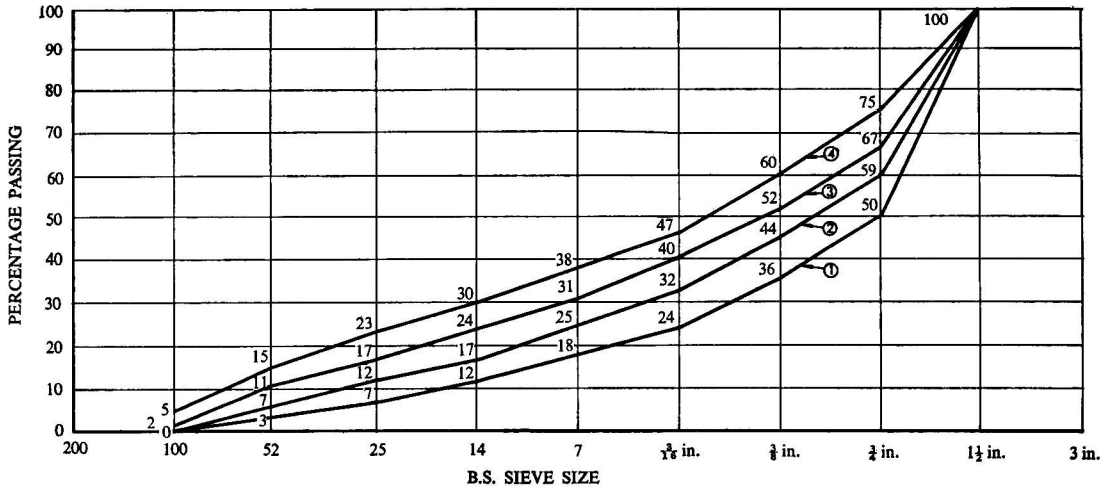

Figure 14: Grading curves for $1\frac{1}{2}$ in. maximum size aggregate.

HIGH-STRENGTH DESIGN DATA
(Chapter 6)

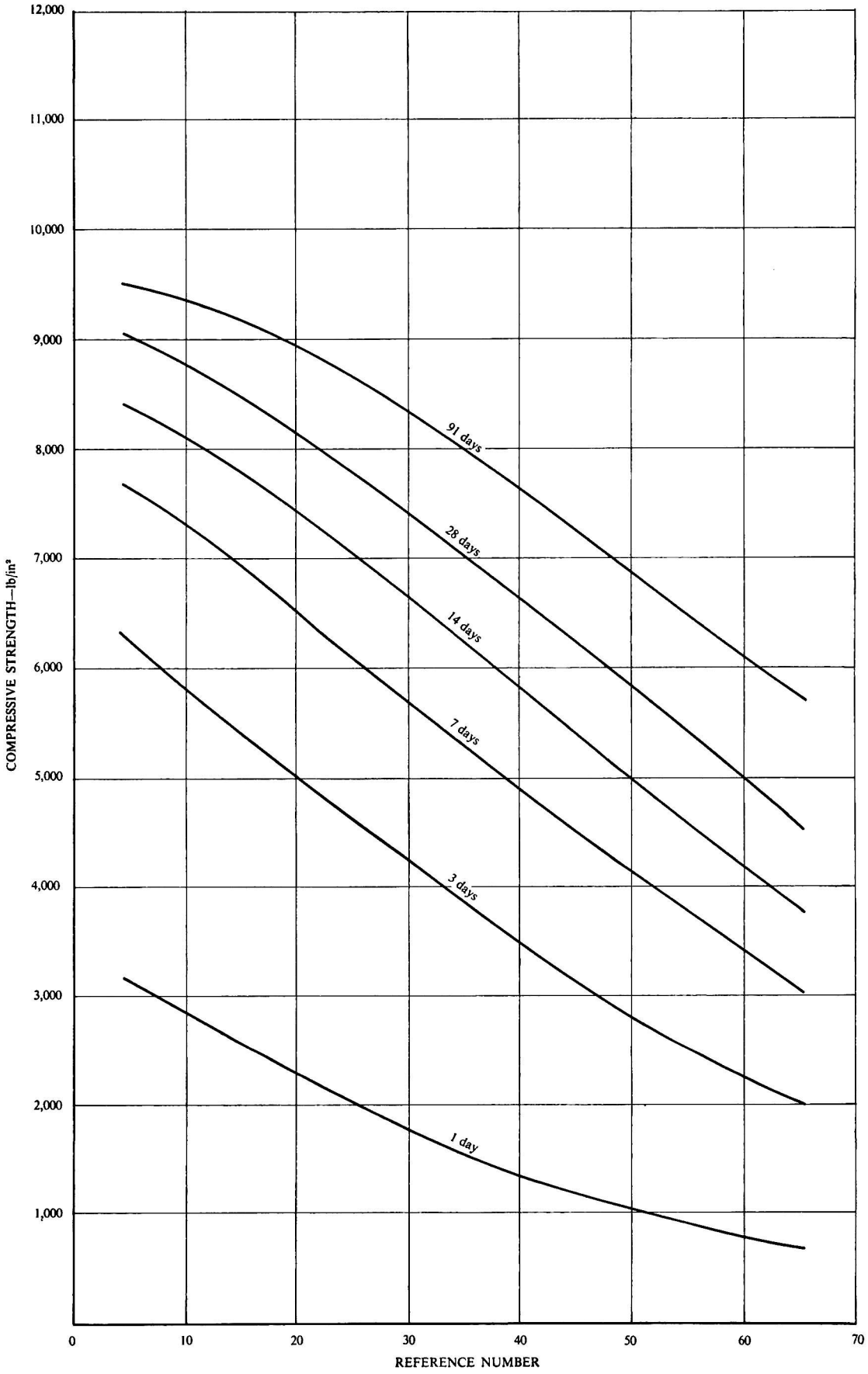

Figure 19: Relation between compressive strength and reference number of concrete made from irregular gravel coarse aggregate, natural sand and ordinary Portland cement.

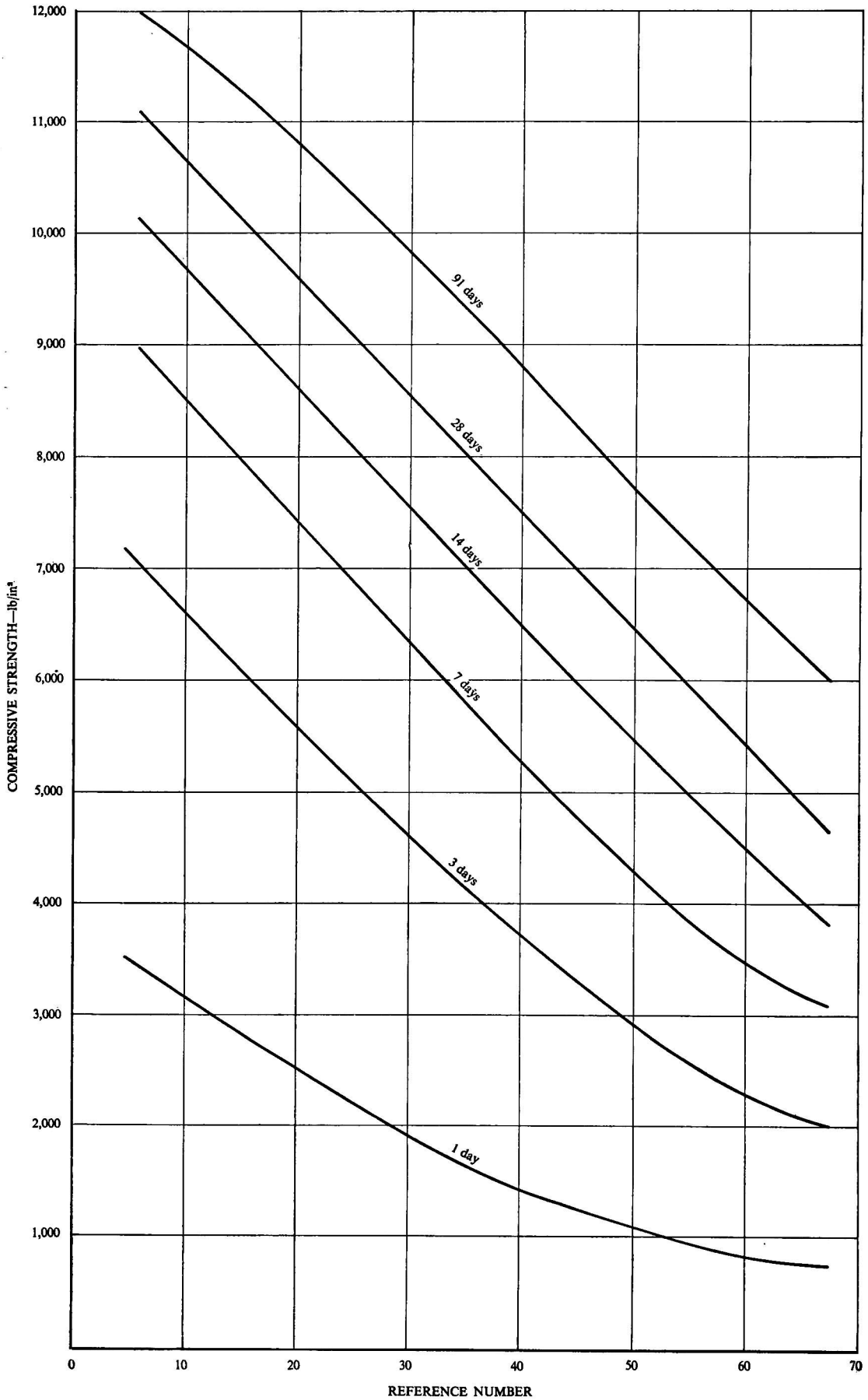

Figure 20: Relation between compressive strength and reference number of concrete made from crushed granite coarse aggregate, natural sand and ordinary Portland cement.

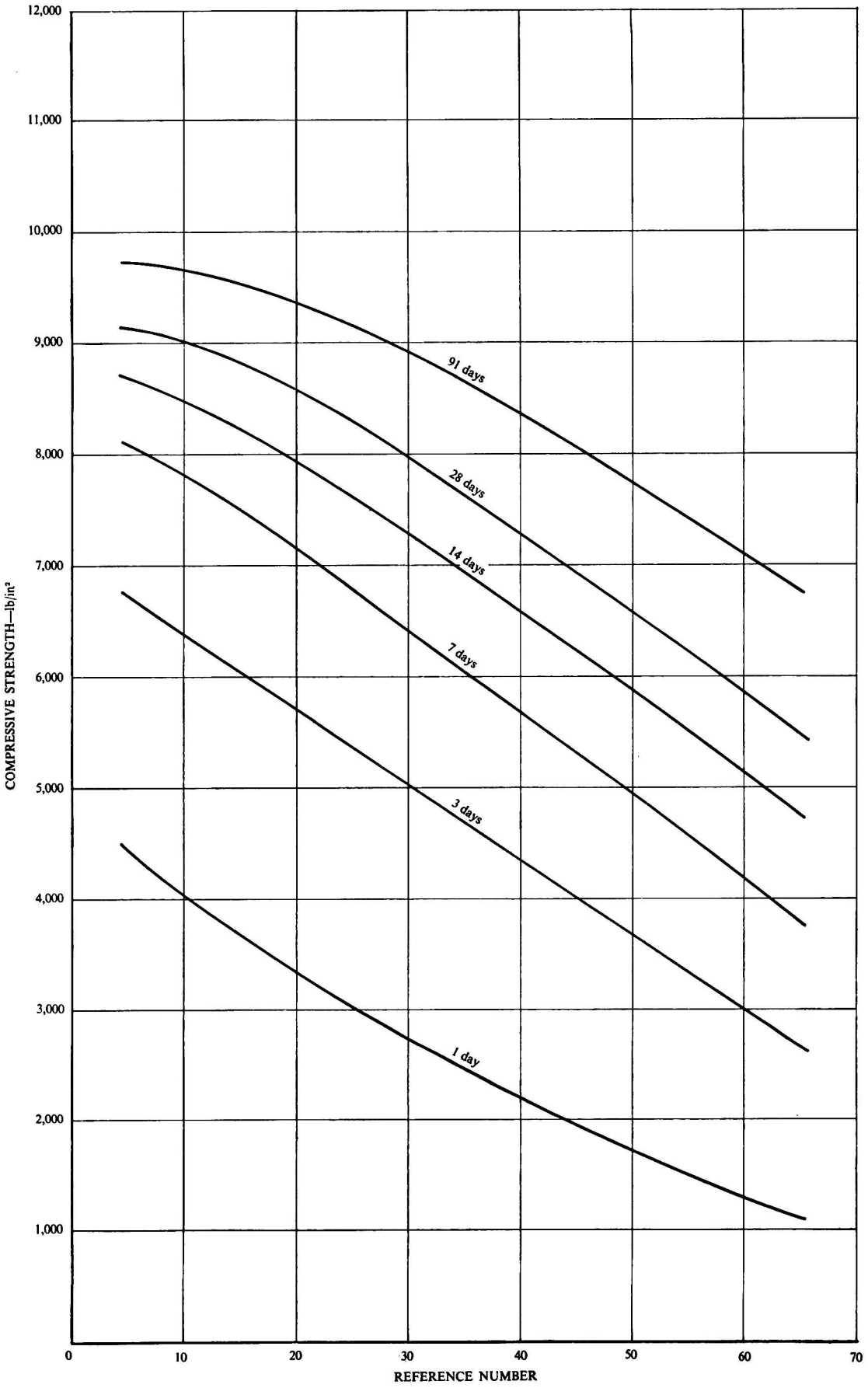

Figure 21: Relation between compressive strength and reference number of concrete made from irregular gravel coarse aggregate, natural sand and rapid-hardening Portland cement.

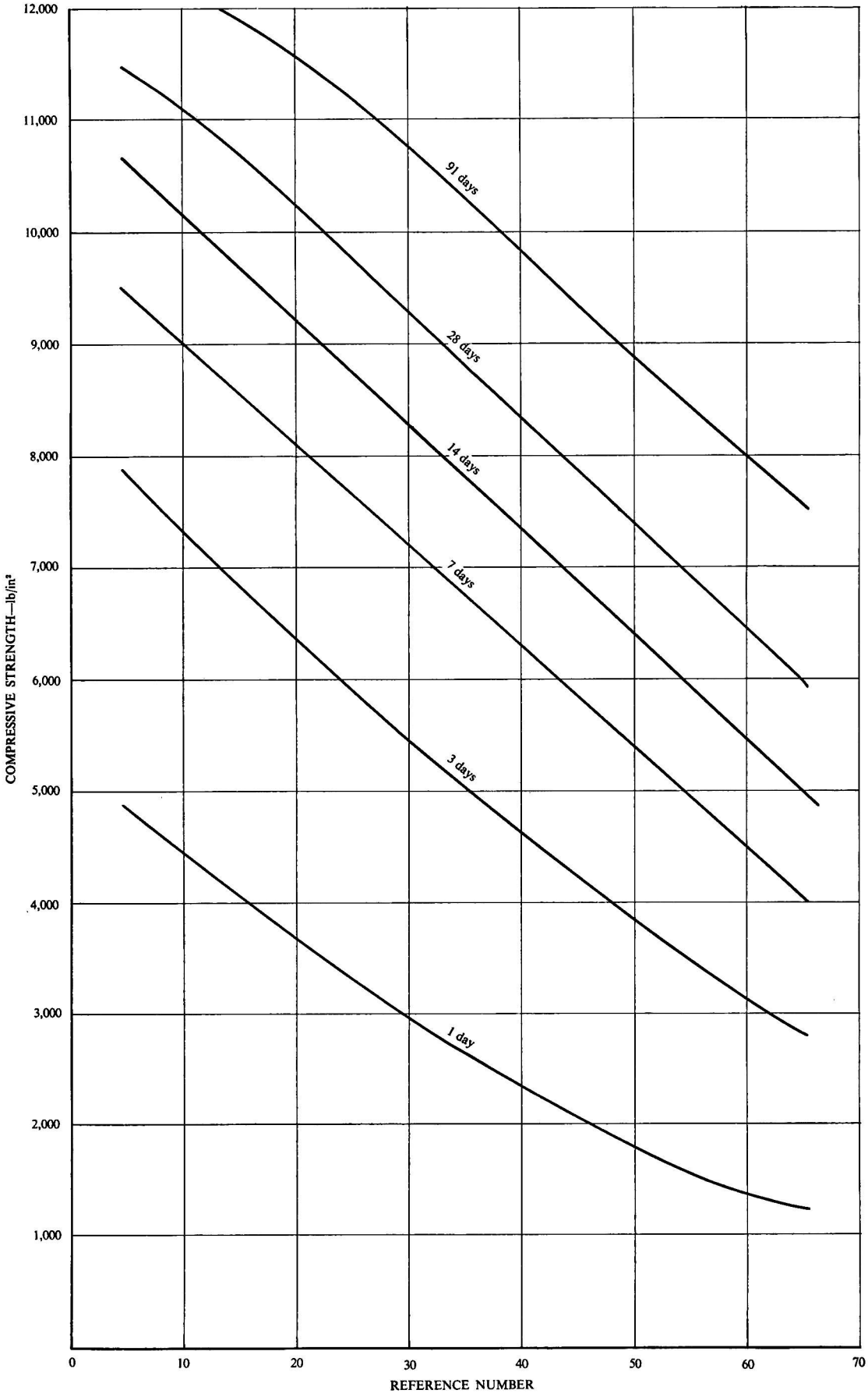

Figure 22: Relation between compressive strength and reference number of concrete made from crushed granite coarse aggregate, natural sand and rapid-hardening Portland cement.

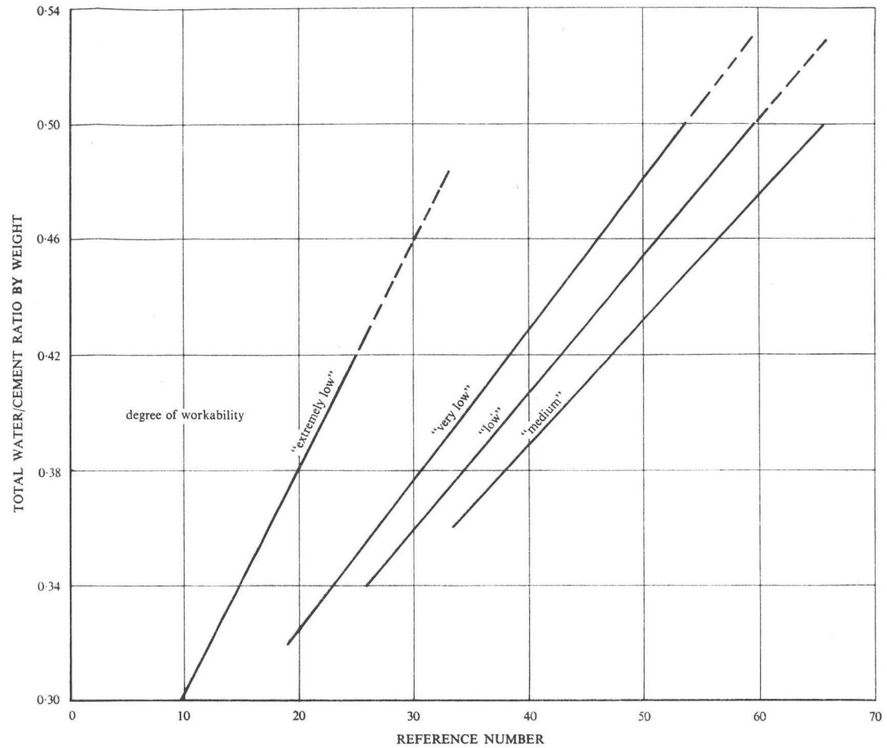

Figure 23: Relation between reference number and total water/cement ratio of concrete made from $\frac{3}{8}$ in. aggregate.

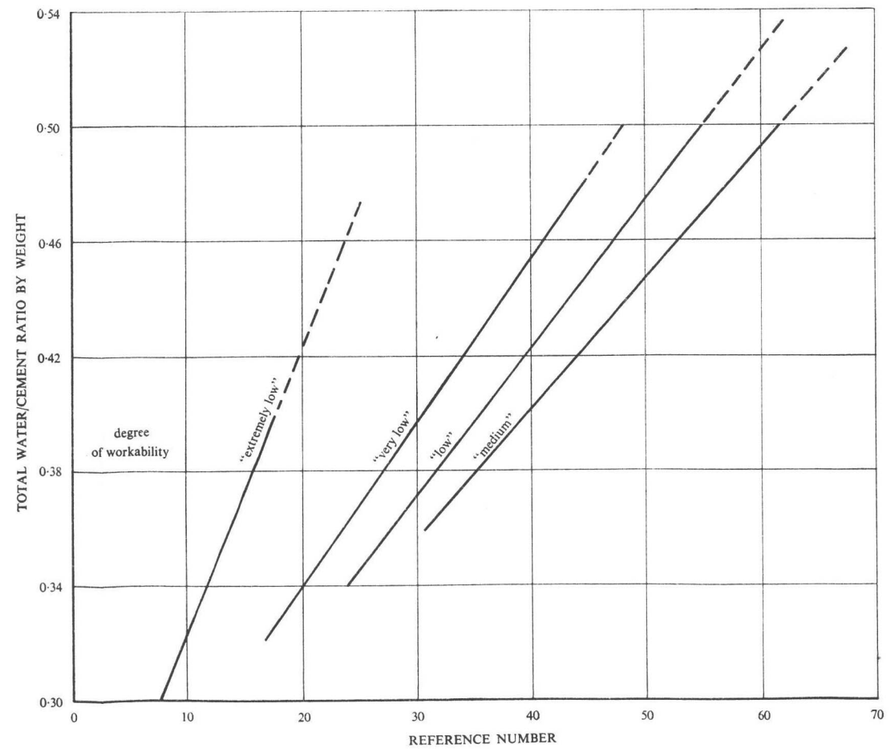

Figure 24: Relation between reference number and total water/cement ratio of concrete made from $\frac{3}{4}$ in. aggregate.

Aggregate/cement ratio required to give four degrees of workability with different water/cement ratios

TABLE 17: ordinary Portland cement

		Aggregate/cement ratio by weight															
*Type of coarse aggregate**		*Irregular gravel*								*Crushed granite*							
Maximum size of aggregate		$\frac{3}{8}$ *in.*				$\frac{3}{4}$ *in.*				$\frac{3}{8}$ *in.*				$\frac{3}{4}$ *in.*			
Degree of workability†		*EL*	*VL*	*L*	*M*	*EL*	*VL*	*L*	*M*	*EL*	*VL*	*L*	*M*	*EL*	*VL*	*L*	*M*
Total water/cement ratio by weight	0·30	2·4				3·0				2·9				3·3			
	0·32	3·2				3·8	2·5			3·6	2·3			4·0	2·6		
	0·34	3·9	2·6			4·5	3·0	2·5		4·2	2·8	2·3		4·6	3·2	2·6	
	0·36	4·6	3·1	2·6		5·2	3·5	3·0	2·5	4·7	3·2	2·7	2·3	5·2	3·6	3·1	2·6
	0·38	5·2	3·5	3·0	2·5		4·0	3·4	2·9	5·2	3·6	3·0	2·6		4·1	3·5	2·9
	0·40		3·9	3·3	2·7		4·4	3·8	3·2		4·0	3·3	2·9		4·5	3·8	3·2
	0·42		4·3	3·6	3·0		4·9	4·1	3·5		4·4	3·6	3·1		4·9	4·2	3·5
	0·44		4·7	3·9	3·3		5·3	4·5	3·8		4·8	3·9	3·3		5·3	4·5	3·7
	0·46		5·1	4·2	3·6			4·8	4·1		5·1	4·2	3·6			4·8	4·0
	0·48		5·4	4·5	3·8			5·2	4·4		5·5	4·5	3·8			5·1	4·2
	0·50			4·8	4·1			5·5	4·7			4·7	4·0			5·4	4·5

TABLE 18: rapid-hardening Portland cement

		Aggregate/cement ratio by weight															
*Type of coarse aggregate**		*Irregular gravel*								*Crushed granite*							
Maximum size of aggregate		$\frac{3}{8}$ *in.*				$\frac{3}{4}$ *in.*				$\frac{3}{8}$ *in.*				$\frac{3}{4}$ *in.*			
Degree of workability†		*EL*	*VL*	*L*	*M*	*EL*	*VL*	*L*	*M*	*EL*	*VL*	*L*	*M*	*EL*	*VL*	*L*	*M*
Total water/cement ratio by weight	0·32					2·6				2·5				2·9			
	0·34	2·8				3·4	2·2			3·2				3·6	2·4		
	0·36	3·5	2·4			4·1	2·7	2·3		3·9	2·5			4·3	2·9	2·4	
	0·38	4·2	2·9	2·4		4·8	3·2	2·8	2·3	4·5	3·0	2·5		4·9	3·4	2·9	2·4
	0·40	4·9	3·3	2·8	2·3	5·5	3·7	3·2	2·7	5·0	3·4	2·9	2·4	5·5	3·9	3·3	2·7
	0·42		3·7	3·1	2·6		4·2	3·6	3·0	5·5	3·8	3·2	2·7		4·2	3·6	3·0
	0·44		4·1	3·5	2·9		4·6	4·0	3·4		4·2	3·5	3·0		4·7	4·0	3·3
	0·46		4·5	3·8	3·2		5·0	4·3	3·7		4·6	3·8	3·2		5·1	4·3	3·6
	0·48		4·9	4·1	3·5		5·5	4·7	4·0		5·0	4·1	3·4		5·5	4·6	3·9
	0·50		5·2	4·4	3·7			5·0	4·3		5·3	4·4	3·7			4·9	4·1

Values in this Table refer to grading No. 1 *of Figures* 12 *and* 13 *for each maximum size.*

* *Natural sand used in combination with both types of coarse aggregate.*

† *EL*="*Extremely Low*"
VL="*Very Low*"
L="*Low*"
M="*Medium*"
} *as defined in Table* 6