EUROPEAN CONCRETE ROAD STANDARDS AND PRACTICES

Raymond Sharp
Cement and Concrete Association
London, England

INTRODUCTION

The basic data in this paper consists of a synoptic table of European Concrete Road Standards and Practices covering twelve countries. In July 1969 with the support of the Permanent International Association of Road Congresses (PIARC), Cembureau (The European Cement Association) organised the first European Symposium for Concrete Roads in Paris. A second Symposium was held in Berne in 1973. For both Symposia the PIARC Technical Committee for Concrete Roads compiled a synoptic table for concrete road standards and practices, the work of preparation being entrusted in both cases to the author.

For the sake of continuity it would be appropriate for a third synoptic table to be prepared in 1977, but because of this International Conference on Concrete Pavement Design at Purdue University no European Symposium for Concrete Roads has been planned. The invitation to present this paper to the Conference provides the author with an opportunity to compile the synoptic table for a third time and to elaborate on the basic statistics which it contains.

SCOPE OF STUDY

The synoptic table includes data on the following countries:

Austria, Belgium, Czechoslovakia, Denmark, France, Great Britain, Netherlands, Italy, Spain, Sweden, Switzerland and West Germany.

This somewhat arbitrary choice was made initially on the basis of membership of the PIARC Technical Committee for Concrete Roads. By choosing those countries represented by individual people, a reliable and willing source of information was assured. It will be seen that all the major Western European countries are included, but the Eastern European countries are represented only by Czechoslovakia. The major concrete road using countries in Europe at present are Austria, Belgium, France, Great Britain, Spain, Switzerland and West Germany although all the remaining countries of the twelve have had recent experience of concrete highways or are contemplating building again in the near future. Denmark is an example of this last category. It is believed that most Eastern European countries have constructed concrete roads although the exact information about the amount and their design is not readily available.

BASIS AND PHILOSOPHY FOR PAVEMENT DESIGN

In common with most engineering decisions, there is a risk element in pavement design. Pavement design decisions cannot therefore be divorced from decisions about long-term financial investment and it would be logical therefore if a decision analysis approach should be part of the process of pavement design. Whilst there has undoubtedly been a move towards these business decision techniques, it would be accurate to say that engineering judgement, which does of course bring in an element of economic assessment, is still the method most used.

The three main factors affecting the thickness design of road pavements are of course, traffic, sub-grade strength, and pavement materials. Future traffic levels are notoriously difficult to predict for any significant time ahead. Although it is impossible to say precisely what the magnitude of the errors in estimating the future growth of commercial vehicles will be, a minimum competence interval of plus or minus 80% seems likely. There is also an element of uncertainty in the validity of the equivalence factors used to relate axle loads to the damaging effect of an equivalent standard axle.

Having pointed out some limitations of the traffic estimating procedures, it is comforting to realise that in fact the pavement construction costs for new roads are relatively insensitive to small variations in traffic estimates, especially for pavements on stronger sub-grades. As a typical example, an increase in concrete slab thickness of 40mm would enable a pavement successfully to carry a ten-fold increase in traffic. On the other hand pavement life is measured in terms of traffic and therefore life and pavement maintenance costs are rather more sensitive to errors in traffic estimates.

Estimates of sub-grade strength are based upon a knowledge of the soil type and how that soil reacts to changes in moisture content in a particular climatic environment and to its compaction state. The variation in factors affecting the supporting power of the sub-grade soil are large but fortunately concrete pavement thickness is relatively insensitive to sub-grade support. The final factor affecting pavement thickness is the quality of the concrete used in the slab. Clearly the higher the strength of the concrete the smaller the thickness can be, but the difficulty is in arriving at an exact relationship. It is illuminating that these studies which have been carried out appear to justify the strength of the concrete in current use! There has been a tendency however to increase cement contents over the last decade.

STANDARDISATION OF DESIGN

Most countries have a standard approach to design which is often mandatory for major traffic roads. In Europe pavement design methods have been evolved as a result of experience over many years aided by research. It is noteworthy that in European countries with a long tradition of building in concrete that theoretical studies, e.g. multi-layer analysis, are not used in individual project cases. Until a few years ago traffic was classified very simply, e.g. into light, medium or heavy, but recently there has been a move to classify traffic more exactly in terms of standard axles. In countries with a very long successful use of concrete pavements it is perhaps not surprising to note that changes in design thicknesses have been very small, at least until recently. It is clear that there has been recognition that there is little value to be gained from tinkering with a system which has been proven to be both successful and economic. However, two factors have brought about change in the last five years. The first is the general abandonment of reinforcement and the second is the growth in commercial traffic and the appreciation of the very great damaging power of heavy axles.

Although there has been a move to rationalise design methods, usually in terms of total numbers of standard axles, somewhat surprisingly this approach has not been fully correlated with absolute life in terms of years. Few countries appear to have a firm idea as to the length of time they wish their constructions to last. One notable exception is Great Britain where a life of 40 years has for some years been the objective. The general philosophy however has been to obtain a life 'as long as possible', and this is perhaps a sound approach, bearing in mind that history indicates that once a road is established in a particular place on a particular line the need for it goes on for many many decades, or indeed for centuries.

OUTSIDE INFLUENCES ON DESIGN

No technical paper is complete without some consideration of factors affecting the issues which are non-technical. One crucial factor affecting the design life of a road is whether it is being provided by a concessionaire who is granted the privilege of gathering tolls. To illustrate the point, over a period of about seven years, very considerable lengths of auto-route were built in concrete in France. Recently however, little has been constructed because of the change to a toll system operated by private interests. Clearly the requirements of the concession in relation to the condition of the pavement at the end of the concession period will effect not only the choice of pavement but also the thickness and design generally.

Even more fundamental is the question as to whether certain types of pavement are encouraged in any particular country. Most governments would accept that competition between construction methods is advantageous as without such competition, a monopoly would develop and the costs of road pavements would tend to rise increasingly with little incentive for research. Despite the direct economic calculations therefore it may be prudent occasionally to select a pavement material or design with the sole purpose of maintaining a competitive concrete and flexible pavement industry in a country and avoid the possibility of a monopoly and consequent higher prices in the longer term. It is conceivable too that influences on policicians may have a direct influence on road construction policies passed on to administrators and engineers responsible for the executive capacity.

Governments tend to keep decisions of this nature to themselves, but it can be reported that the British Government has publicly adopted the policy of maintaining at least 20% of major highway construction in concrete. The current figure is about 16% and it must be stated that so far no real positive action has been taken at Government level to implement the stated policy.

Official policy has also affected designs at a more mundane level. Some countries favour flexible materials or special designs in concrete on weak sub-grades in mining areas or on high embankments. There is now however, an almost complete acceptance that there are no technical reasons why a concrete pavement should not perform satisfactorily whatever the nature of the sub-grade or climate. Excessive deflexions that occur in mining subsidence areas can be dealt with by appropriate design features, e.g. reinforcement and joint articulation. Some concrete roads performed badly on embankments, but it is now widely realised that the failure was in the embankment rather than in the concrete. Modern earth-moving plant, properly used, with adequate control of compaction coupled with the choice of the right material and moisture content has resulted in embankments which are reliable and which often provide better performance to the overlying pavement than does the natural soil at grade.

AVAILABILITY OF MATERIALS AND PLANT

When constructing any form of road there is clearly a great cost advantage in using local materials. Cement is universally available at a reliable price in Europe and suitable aggregates are also usually to be found within reasonable haul distance. The large quantities of materials needed for a major road contract mean that it is very often economically possible, as well as being convenient, for contractors to set up a special quarry or pit solely for one contract. Generally in Europe aggregates are of high quality although suitable sand is sometimes not to be found locally and has to be imported from an adjoining region.

No problems have developed in Europe in making available suitable construction plant for both small and large projects. European manufactured plant is available from Belgium, Great Britain and West Germany. American manufactured slip formed pavers have also been imported and used extensively.

SELECTED DESIGN DETAILS

It is now proposed to examine some individual features of concrete pavement design and to comment on the different approaches used in various European countries.

Basic Design Requirements

There is a continuing tendency to move away from designing for numbers of commercial vehicles towards the more exact approach of summing standard axles throughout the life of the road or for assuming a particular number of standard axles for different types of pavements. The maximum axle loads permitted vary from 10 tonnes in a number of countries to 13 tonnes on single axles in Belgium and France. Efforts to standardise axle loads in European Economic Countries (EEC) so far have not been successful. For motorways, slab thicknesses range from 200mm to about 280mm for plain concrete. Continuously reinforced concrete is extensively used only in Belgium and a 30mm reduction over plain concrete is permitted with this design.

Reinforcement

Reinforcement as opposed to continuous reinforcement is permitted in certain countries, e.g. Great Britain, Netherlands, Spain and Switzerland. In almost all countries the standard practice now is to use plain concrete slabs because they are cheaper than reinforced slabs and the incorporation in designs of dowels at joints and stabilised sub-bases has resulted in very good performance. Only in Switzerland is reinforcement still used regularly and this is at a relatively light weight being largely confined to slab edges. This design has been used very successfully for many years. In Great Britain designs for both plain and reinforced slabs are available, the same concrete thickness being used with the choice being left to the contractor on the basis of cost. The result of this is that no reinforced slabs have been laid for some years. Continuous reinforcement has been extensively used in Belgium and several countries, including France, Germany, Great Britain, Netherlands and Spain, have carried out trials. So far none of these last countries has adopted continuously reinforced pavements for general use, possibly because of the increased initial cost, though the programme has still to be fully evaluated.

Sub-Bases

Over the years cement treated sub-bases have become increasingly used under concrete pavements although in some countries, particularly France and West Germany, other materials like lime and bitumen are utilised. The thickness of sub-bases varies considerably from 80mm to 600mm, the very great thicknesses being provided as a frost blanket to protect the sub-grade soil from freezing. For structural and/or constructional purposes a thickness of 150mm to 200mm is probably a reasonable average.

The materials used for cement treatment are almost always granular in nature, but they vary from high class concreting aggregates optionally used as lean concrete in Belgium, France and Great Britain to poor quality as-dug sand/gravel material. These cemented materials are almost always tested by means of compressive strength and full details will be found in the synoptic table. Other tests are also used, such as California bearing ratios, dry densities, cement contents, optimum moisture contents and resistance to freezing and thawing. The use of natural granular materials without treatment under concrete pavements is declining for major roads although these materials are still frequently used for the more lightly trafficked slabs.

Joints

Expansion joints are almost universally confined to special points, such as bridges. Austria in addition, requires them when pavement thicknesses change and Great Britain is unique in still requiring expansion joints when construction is carried out in the colder months. Contraction joint techniques are interesting and exhibit great variety. Spacing varies between 4m and 6m for unreinforced concrete, skewed joints being specified in Denmark, France and Spain. Austria has successfully used unsealed contraction joints for some years and these are 3mm wide only. Other countries, particularly Spain and Switzerland have experimented with unsealed joints.

The reduction in slab section in contraction joints varies from 20% to 50% depending upon whether bottom crack inducers are used. There has been a tendency away from the use of crack inducers and towards the adoption of a single groove at the top of the slab, probably because of the greater reliability of performance in the second alternative. The sawing of joints is more popular than wet-formed vibrated methods although the latter methods are extensively used in many countries and are considered almost essential with some types of hard siliceous aggregates.

Load Transfer at Transverse Joints.

A very interesting situation is revealed by a study of load transfer at transverse joints. A positive method, e.g. dowel bars, is used in most countries, but in others, notably France, it has been decided to rely upon a rigid sub-base to provide load transfer across contraction joints. In almost all cases dowel bars are now inserted using a mechanical dowel bar spacer, but problems arise with slip-form paver construction as effective placers which do not need rails upon which to run are still in the development stage. France is changing over to the use of lean concrete forsub-bases in order to reduce any potential for pumping of sub-base materials at joints. It is claimed that this is a cheap method of overcoming a possible difficulty whilst dowels would increase the cost of the total pavement. Other countries, e.g. Austria, Great Britain, Switzerland and West Germany, with a long tradition of concrete road construction, insist that load transfer by dowel bars is essential but behind this choice is an interesting example of the effect of construction techniques on design. In many European countries slip-form pavers have not been extensively used as in North America , one reason being that in order effectively to introduce dowels into concrete pavements it has been considered necessary to use rail bound equipment to carry dowel bar placers. These are now favoured both for the accuracy of results and for economy compared with dowel bars held in steel fabric baskets secured to the sub-base in advance of the paving machinery.

Longitudinal Joints

Wet-formed and sawn longitudinal joints are used depending upon the width of the slab which is cast with one pass of the machinery. Efficient and effective wet-formed longitudinal joints have been developed in recent years and are generally cheaper than sawn joints. In Europe tongued and grooved joints are not generally used, one exception being the Netherlands, but tie-bars are almost always incorporated at longitudinal joints. This method of tying has proved both cheap and effective over many years.

Concrete

Almost all countries specify the compressive strengths, either cubes or cylinders, for their pavement quality concrete, an interesting exception being Great Britain which specifies the indirect tensile test on cylinders. It is difficult to compare the strength requirements of the various countries because of the different methods and times of test. More details are given in the synoptic table.

No special cements are used for roads except in Czechoslovakia, ordinary Portland cement or Portland blastfurnace cement being almost always used. Sometimes the maximum C_3A percentage is specified, e.g. Spain - 10%, France, Czechoslovakia - 8%. The practice of specifying minimum cement contents is common, the usual figures varying between 300kg and 330kg/m^3, although there are exceptions above and below these figures. Maximum water cement ratios are at times specified, e.g. in Spain and Great Britain, where the figure is 0.55. The properties of the concrete used, in particular the selection of strength, is of course important in any consideration effecting pavement thickness design and some discussion has already been included on this aspect earlier in this paper.

Almost all countries require the use of air-entrained concrete, a minimum figure commonly being 3% with a maximum of 6%. Comprehensive details about the properties of the fine and coarse aggregate, on the mixing of the concrete, and on the paving and finishing are included in the synoptic table, but as they are not directly related to design a discussion on them is omitted here.

Surface Finish and Texture

A design decision has to be made concerning the type of final finish and texture to be placed on the surface and the almost universal use of the broomed finish is now changing under the influence of the desire to increase high speed wet skidding resistance. Considerable experimental work has been carried out, e.g. in Belgium and Great Britain to develop grooving techniques and they are undoubtedly effective in producing a surface not only with a good high speed skid resistance but one which retains high figures for long periods. The increased noise however which occurs with increase in roughness with any surface, whatever its material, has produced a user reaction. This has highlighted one of the difficult problems facing engineers in producing a balance between what is technically or economically correct and very safe, with the apparent desires of the public. Work has also been done particularly in Belgium and Denmark in developing an exposed aggregate surface by mechanical means and these are very effective provided a stone with a low polishing characteristic in the long term is chosen. Skidding resistance in the initial stages can be some guide to long term performance and for this reason in Belgium, Denmark, France, Great Britain, The Netherlands and Switzerland, some attempt is made to express skidding resistance requirements in terms of aggregates used or through tests carried out on the completed pavement by skid testers and texture depth measurers.

SPECIFYING AUTHORITIES

Public highways are financed at government level and for this reason designs for major roads are almost always issued by a government department or by a body carrying the authority of central government. Most countries have a long history of issuing standard designs and specifications and the date of the latest version is given in the final column of the synoptic table. None is older than 1972 and many are very recent.

CONCLUSIONS

Concrete pavements designed with the present knowledge behave very well and long life can be confidently predicted. When failures occur it is true to say that there is always a valid reason and that with hindsight the problems could have been avoided. As a generalisation it can be said that very few problems now arise with the slab itself, the sub-base and sub-grade soil usually providing the source of the weakness when one develops. This no doubt explains why in recent years greater attention has been paid to these elements in concrete pavements.

Although there are considerable differences in philosophy and design approach, material and construction methods, techniques etc., used in the various countries reviewed, it is noteworthy that successful concrete pavements have been built in all of them. It must be concluded therefore that there are many and various approaches to the design and construction of concrete road pavements and any attempt to superimpose a completely uniform approach is not justified. Individual climatic, traffic, geographic and economic conditions all play their part, and added to this list must be the individual philosophical and character based approach of the nations involved.

ACKNOWLEDGEMENTS

The author is indebted to his many friends and colleagues concerned with the concrete road field in Europe. Many have assisted in producing the information and impressions presented in this paper. Particular mention must be made of the following who have produced up-to-date information for inclusion in the synoptic table:

Dr H Sommer	(Austria)
A Doyen	(Belgium)
E Slachta	(Czechoslovakia)
G Christiansen	(Denmark)
M Ray	(France)
B J Walker	(Great Britain)
Prof. G Moraldi	(Italy)
C Van de Fliert	(Netherlands)
Dr C Kraemer	(Spain)
Dr I Karlsson	(Sweden)
W Wilk	(Switzerland)
P Misch	(West Germany)

INTERNATIONAL CONFERENCE ON CONCRETE PAVEMENT DESIGN

PURDUE UNIVERSITY, FEBRUARY 1977

EUROPEAN ROAD STANDARDS AND PRACTICES

BY RAYMOND SHARP

SYNOPTIC TABLE OF EUROPEAN CONCRETE ROAD STANDARDS AND PRACTICES

CEMENT AND CONCRETE ASSOCIATION
52 Grosvenor Gardens
London SWI WOAQ
ENGLAND

Basic Design Requirements - Main Roads (MR) / Prescriptions applicables à la construction - Routes principales (MR) / Allgemeine Baurichtlinien - Hauptstraßen (MR)

Design traffic (commercial vehicles per day) Trafic de base (nombre de camions par jour) Verkehrslast (LKW/Tag)	Max. axle or wheel loads permitted Charge maximale permise par essieu ou par roue Höchstzulässige Achs- oder Radlast	Thickness Epaisseur Dicke mm	Type of crown or crossfall and amount Pente transversale et pourcentage Quergefälle bzw. Dachprofil %	Width of traffic lanes / Largeur des voies / Fahrspurbreiten Normal width Largeur normale Spurbreite m	Marginal strips Bande de guidage Randstreifen m	Parking lane Bande de stationnement d'urgence Standspur m	Lane for slow traffic Voie supplémentaire en rampe Kriechspur m
9	10	11	12	13	14	15	16
N	R Single axle 10 t Tandem axle 16 t	R 220 200 over cement or bituminous subbase 200-250 thick	A 2 straight crossfall	A 2 x 3.00 to 3.75	N.E.	A	E
No design	Axle load 13 t	Plain concrete (unreinforced) 230 Continuously reinforced concrete 200	A 1.5-2.0	3.5-3.75	A 0.5-1.0	A when existing 2.0-3.0	N.E.
500-1000	Single axle 10 t	200-220	R 1.5	7.0 (2 x 3.50)	0.50	2.50	A 3.50
	R Single axle 13 t Tandem axle 20 t (10 t per axle)	N 230-250	A 2 straight crossfall	R 3.50	A 0.25	A 2.0-3.0 when used	A 3.50
Design based on total standard axles carried during total life	Single axle 10 t	A 220-270	2.5 straight crossfall	A 3.65	A 1.0	3.0 lay-bys	A 3.65
Approx. 2000-3000	Maximum wheel load 5 t	250 concrete 150 tar-line stabilisation	1.5-2.0	3.50	2 x 0.45	2.75	N
N	Single axle 12 t Tandem axle 19 t	N 220	R 1.5-2.0	R Mainly 3.75	R 0.12-0.20 white painted line	R 1.0-1.5	N
Design based on total 13 t standard axle loads for 30 years	Single axle 13 t Tandem axle 21 t	R 210-250	R 1.5-2.5	R 3.50-3.75	R 0.15	R 1.5-3.0	R 3.0
300-900	Single axle 10 t Tandem axle 16 t	200	2.0 crown	3.5	0.5	3.00 or 1.00	3.5
A 1000-2000 (sum in both directions)	Single axle 10 t Tandem axle 16 t	180-220	1.5 crown or 1.5-6.0 straight crossfall	3.50			3.50
R 1500-3000	Single axle 10 t	R 200	R 2.5% straight crossfall	2 x 3.75 = 7.50	R 0.50 outside and inside	R 2.50	R 3.75

Basic Design Requirements - Secondary Roads (SR) / Prescriptions applicables à la construction - Routes secondaires (SR) / Allgemeine Baurichtlinien - Nebenstraßen (SR)

Design traffic (commercial vehicles per day) Trafic de base (nombre de camions par jour) Verkehrslast (LKW/Tag)	Max. axle or wheel loads permitted Charge maximale permise par essieu ou par roue Höchstzulässige Achs- oder Radlast	Thickness Epaisseur Dicke mm	Type of crown or crossfall and amount Pente transversale et pourcentage Quergefälle bzw. Dachprofil %	Width of traffic lanes / Largeur des voies / Fahrspurbreiten Normal width Largeur normale Spurbreite m	Marginal strips Bande de guidage Randstreifen m	Parking lane Bande de stationnement d'urgence Standspur m	Lane for slow traffic Voie supplémentaire en rampe Kriechspur m
17	18	19	20	21	22	23	24
1							
No design	Axle load 13 t	200-230	A 1.5-2.0	A 3.00-3.50	A 0.50	A	none
100-500	Single axle 10 t	180	1.5	6.00 (2 x 3.00)	0.25	1.50	N
Design based on total standard axles carried during total life	Single axle 10 t	A 200-250	2.5 camber or straight crossfall	A 3.65	none specified	3.0 lay-bys	A 3.65
Up to 2000 vehicles Also bicycles	Maximum wheel load 5 t	120-180 concrete No stabilisation	1.5	Total width 3-6			
N	Single axle 12 t Tandem axle 19 t	N 200	R 1.5-2.0	R mainly 3.75	R 0.12-0.20 white painted line	R 1.0-1.5	N
Design based on total 13 t standard axle loads for 30 years	Single axle 10 t Tandem axle 16 t up to 13 t - 16 respectively by special license	R 180-220	R 1.5-2.5	R 3.00	R 0.10	R 0.50-1.50	Not used
Concrete pavements not used as a rule							
100-1000 (sum in both directions)	Single axle 10 t Double axle 16 t	A 160- 200	1.5 crown or 1.5-6.0 straight crossfall	3.00			
R 500-1500	Single axle 10 t	R 200	R straight crossfall 2.5	R 3.75	R 0.5	R 3.75	R 3.75

Sub-Base Materials / Couches de Fondation / Unterbau									
Cement Treated Traitées au ciment Unterbau mit Zement				Other Materials Autres Matériaux Unterbau mit anderen Materialien					
		Requirements Exigences Anforderungen				Requirements Exigences Anforderungen			
						Grading Granulométrie Kornabstufung			
Material used Nature des matériaux Benutzte Baustoffe	Thickness Epaisseur Dicke mm	Compressive strengh (7 days or others) Résistance à la compression (à 7 jours ou autres exigences) Druckfestigkeit (7 Tage oder andere Alter)	Other tests Autres essais Andere Versuche	Materials used Nature des matériaux Benutzte Baustoffe	Thickness Epaisseur Dicke mm	Max. size Dimensions maximales Größtkorn mm	Passing 75 micron sieve du passart au tamisde 75 microns Durchgang durch 0.075-mm-Sieb %	Density required Densité imposée Geforderte Dichte	Surface Accuracy Tolérance de surfaçage Geforderte Ebenheit
25	26	27	28	29	30	31	32	33	34
Crushed stone	250-350	Lab 30 kg/cm² at 7 days		R Hot bitumen gravel	100-185 depending on amount of construction traffic	E 25			R 10 mm under 4 m straight edge
A Crushed stone Gravel Lean concrete	A 200-350 180-200	R 56 days compressive strength (R 56) 75 < R56 < 200 for lean concrete 75 < R56 < 300 for reinforced lean concrete	R 100 < CBR < 300 for crushed stone or gravel	Dense bitumen binder	60 Isolation layer	R 22	< 7 on cores	R Voids content 0 to 5% on cores	R 4 mm under 3 m straight edge on isolation layer
Gravel and sand natural granular 0-45 mm	250	R 10-25 kg/cm²	Dry density cement content optimum moisture content thickness freezing-thawing	a) Hot bitumen gravel b) Penetrated macadam		a) 45 b) 125		min. 95% Marshall	20 mm under 4 m straight edge
Cement bound granular	150	≧ 30 kg/cm² specified 40-50 kg/cm² obtained	dry density 95% density in field						
R Gravel and sand 0.20 mm cement content 3.5-4.0% cement class 325 or lean concrete	A 150	N 44-55 kg/cm²	R Immersion/compression ratio > 0.75 Dry density > 95% Modified Proctor density for 95% of results	R 15-20% granulated slag 1% lime Porous lean concrete under shoulders	R 150	R 20-25	R < 4	R Modified Proctor density	R ± 5 mm under 3 m straight edge
Soil-cement Cement bound granular Lean concrete	0-250	Average not less than 35 kg/cm² for 7 days Average 70-140 kg/cm² — 7 days	Optimum moisture content determined by vibrating hammer method test Dry density	Crushed rock, concrete or grandular	0-280	75	0-10	Method specification for compaction	R +10 to -3 mm from true level
Sand-cement	150-400	Lab at 60 kg/cm² at 28 days Cores mean 40-80 kg/cm² at 90 days	Density and water content	Tar/Lime stabilized sand	150		12	100% standard Proctor	± 10-15 mm
R Crushed stone Sand and gravel	R 150-200	≧ 30 kg/cm² ≦ 70 kg/cm²	R Dry density optimum moisture content	E Sand-gravel pozzolano	E 200-250	E	E	E 95% modified Proctor	R ± 1 cm
R (i) crushed stone 3.0-4.5% cement content (ii) soil cement	R (i) 150 (ii) 150-200	R (i) Min. 35 kg/cm² (ii) Min. 20 kg/cm²	R Dry Density (i) Min. 97% Mod. Proctor (ii) Min. 100% Mod. Proctor	R Sandy gravel	R 150	R 25-50	R Usually 5-15	R Min. 95% modified Proctor	R 10 mm under 3 m straight edge
Poor quality gravel	150	≧ 35 kg/cm²		Well graded good quality gravel		50	Max. 10 Min. 2	N	12 mm under 5 m straight edge
Poor quality gravel	A 150-300	R 20 kg/cm²	N Freezing/thawing	Natural granular	200-600	R 100	N 5	103% Standard	+ 0 − 20 mm
R Sand or gravelly sand	R 150-250	R 50-80 kg/cm² (28 days) 25-40 kg/cm² at 7 days	under 4 m straight edge	R Lime, tar & bitumen	150 for lime & tar 80-100 for bitumen	R 32		N	10, 15 or 20 under 4 m straight edge depending on material

Joints / Joints / Fugen

Transverse Expansion / Joints de dilatation transversaux / Querraumfugen

Spacing Ecartement Abstand m	Width Largeur Breite mm	Type of filler and sealer required Corps de joints et produits de scellement Art der geforderten Fugenfüllung bzw. Abdichtung	Width of sealing groove Largeur de la rainure de scellement Breite des Vergußspaltes mm	Depth of sealing groove Profondeur de la rainure de scellement Tiefe des Vergußspaltes mm
35	36	37	38	39
R Only at bridges and when pavement thickness changes	R 18	R Wood with bituminous compound	R 18	R 30
A Only near bridges and curbs	R 10	R Timber or expanded cork	R 10	R 40
A	A 20	A Bottom = wood Top = bituminous filling	A 20	A
Only at bridges	A 20	A	A 20	A 40
R Only at special points	R 20-30	E Impregnated softwood or bituminous material	A 20-30	20-30
Omitted for summer construction. Winter (i) Plain: depending upon aggr. 60-72 (ii) Reinforced 63-126 depending on aggregate and reinforcement	25	Knotfree softwood or other compressible materials (P) Hot or cold poured sealing compound or preformed neoprene compression sealing strip (E)	30	Hot poured 25-30 Cold poured 20-25
Only at bridges	10-20	Softwood bitumen latex	10-20	25-30
R Only at special locations	E 20	R Wood with bituminous compound	R 20	E 20-30
R Only at bridges and curves under 200 m radius	R 15-18	R Softwood, korkpack or other compressible material hot or cold formed sealing compounds or preformed neopreme compression sealing strip	R 20	R Min. 30
Only at bridges	20			
Only at bridges	18	Impregnated timber or prefoam and mastic	20	30
E Only at bridges	R 18	Bottom = wooden joint board Top = bituminous filling material according to German DIN 1996 requirements or rubber or plastic inserts	R 20	R 1.5 x width

Joints / Joints / Fugen						
Transverse contraction / Joints de contraction transversaux / Querscheinfugen						
Spacing (i) Plain (ii) Reinforced Ecartement (i) béton ordinaire (ii) béton armé Abstand (i) unbewehrt (ii) bewehrt m	Width Largeur Breite mm	Reduction of section Réduction de la section Querschnitts-schwächung %	Crack inducer details Détails des dispositifs de fissuration provoquée Einzelheiten der rißerzeugendén Fugeneinlagen	Type of sealer required Nature du produit ou matériau de scellement Art der geforderten Fugenfüllung	Construction method Méthode de construction Herstellungs-verfahren	Other types of transverse joints used Autres types de joints transversaux Andere Querfugenarten
40	41	42	43	44	45	46
R 4.0-6.0 no reinforcement	R 8 when sealed or 2-3 unsealed	R 50	X	R Bituminous compound when used	R Sawn after 8-24 hours	R Butt joints: days end sawn: 8 x 20 mm bitumen filler
R (i) 6 (ii) without	R 4	R > 30	R Bottom: asbestos cement Top: sawn	A Bituminous compound	N sawn	R Construction joints at the end of each day's work without filler
R 4.5-6	2.5-3.5	R 20-25			Sawn	
R (i) 5 Skewed 1.6	R 2	R 50	Top inducer 50 mm deep	Hot or cold poured sealing compound in the top 5 to 10 mm	R Sawn	None
A (i) 4.5-6.0 Note: reinforced concrete almost never used	R 4-6	A 20		A.E Bituminous material or Preformed neoprene or Polyurethane or Silicones	R Sawn	R Construction joints at the end of each day's work or at serious interruptions
(i) 5.0-6.0 depending upon aggr. type (ii) 21.0-42.0 depending on aggr. & reinforcement eight	R (i) 10 (ii) 20-40	25-33	Timber, steel or synthetic fillet	E Hot or cold poured sealing compound or Preformed neoprene compression sealing strip	Wet formed or sawn	Warping joints
5	4-8	50-70	N	Bitumen-latex compound	Sawn	
(i) 4-7 for slipform (ii) 5-7 for traditional construction	R 5 for slipform 6-8 for traditional construction	R 20-25		E Bituminous compound	R Sawn or vibrated	
R (i) without dowels; 4-6 skewed at variable intervals with dowels; 5 (ii) 8-12	R Max. 3.5 when unsealed or min. 6 when sealed	R Min. 22	R None	R When sealed, hot or cold formed sealing compound or performed neopreme compression sealing strip	R Sawn or wet formed	R Construction joints at the end of each day's work
(i) 5	4	20	Not used	N Hot poured bituminous sealer containing rubber often used	Sawn joint grooves as well as formed have been used	None
N (i) 5-6 (ii) 6-7	N 5-8	30	Top: Sawn or obestos plastic strip	OC Mastic	A Vibrated or sawn	None
R (i) 4.0-6.0 (ii) 4.0-6.0	R 8	R 25% of thickness at top	R N for bottom inducer	R Bituminous filling material according to German DIN requirements, or plastic or rubber inserts	Sawn or Vibrated	R Butt joints

Joints / Joints / Fugen Load transfer at transverse joints / Dispositif de transfert des charges aux joints transversaux / Lastübertragungsmittel bei Querfugen (i) Dowel dia. (ii) length (iii) spacing / (i) Diamètre (ii) longueur (iii) écartement des goujons / (i) Dübeldurchmesser (ii) -länge (iii) -abstand mm Expansion joints / Joints de dilatation / Raumfugen	Contraction joints / Joints de contraction / Scheinfugen	Other types / Autres types de dispositifs / Andere Lastübertragungsmittel At expansion joints / Aux joints de dilatation / Bei Raumfugen	At contraction joints / Aux joints de contraction / Bei Scheinfugen	Longitudinal / Longitudinaux / Längsfugen Sawn / Sciés / Geschnitten Width / Largeur / Breite mm	Depth / Profondeur / Tiefe mm	Other types / Autres types / Andere Fugenausführungen Type / Description du joint / Art	Width / Largeur / Breite mm	Depth / Profondeur / Tiefe mm	Tie bars (i) diameter (ii) length (iii) spacing / Barres de liaison (i) diamètre (ii) longueur (iii) écartement / (i) Ankerdurchmesser (ii) -länge (iii) -abstand mm	Type of sealer required / Nature du produit ou matériau de scellement / Art der geforderten Fugenfüllung
47	48	49	50	51	52	53	54	55	56	57
R (i) 26 (ii) 500 (iii) 300 Reduced number if bound subbases used	R (i) 26 (ii) 500 (iii) 300 Reduced number if bound sub-bases used			R 8	R 50		R 8	R 20	(i) 20 or 14* (ii) 1000 or 700* (iii) 3 per slab *Op≧50KP/mm²	Bituminous compound
R (i) 25 (ii) 600 (iii) 300	R (i) 25 (ii) 600 (iii) 300			R 4	R 60-70				R (i) 15 (ii) 600 (iii) 750	R Bituminous compound or plastic strip
				2.5-3.5	50					Bituminous compound
(i) 20 (ii) 500 (iii) 300						OC Wet formed with performed strip	3	50	(i) 14 (ii) 660 (iii) 500	Performed sealing strip
A (i) 20 (ii) 400 (iii) 300	None	None	None	R ≤6	R 1/5 of slab thickness	OC Plastic strip put in the fresh concrete		R 50-60	E Tie bars tend to be omitted	AE Bituminous material or preformed neoprene or polyneothene
R (i) 25-32 (ii) 650-750 (iii) 300	R (i) 20-25 (ii) 400-600 (iii) 300	X	X	P 5	P 1/8-1/3 of slab thickness	Wet formed with pre-formed strip	5	A 1/8-1/3 of slab thickness	(i) 12 (ii) 1000 (iii) 600	OC Hot or cold poured sealing compound or preformed sealing strip installed in the wet concrete
	(i) 25-30 (ii) 600 (iii) approx. 300			4	60 or 1/3 of slab thickness	Tongued and grooved const. joint.			(i) 8 (ii) 800 (iii) 500	Bitumen latex compound
R (i) 30 (ii) 600 (iii) N	(i) 22 (ii) 600 traditional construction (iii) N Slipform none	None	None	6-8	60	Plastic strip in the fresh concrete	2	60	R (i) 16 (ii) 800 (iii) 750	R Bituminous filler
R (i) 25 (ii) 500 (iii) 300	(i) 25 (ii) 500 (iii) 300 or none (P or M, MR)	None	None	R 6-8	R Min. 22% of slab thickness	R Wet formed with plastic strip construction joint	N	R Min. 22% of slab thickness	P (i) 12 (ii) 800 (iii) 1000	R Hot or cold poured sealing compound or preformed neopreme compression sealing strip when sawn
				4	20	None			(i) 12 (ii) 1000 (iii) 1000	Prefabricated strip
(i) 22 (ii) 500 (iii) 250	(i) 20 (ii) 500 (iii) 500	None	None	5-8	30	None			N (i) 12 (ii) 600 (iii) 500	OC Mastic
(i) 25 (ii) 500 (iii) 300 at the edges 150	(i) 25 (ii) 500 (iii) 300 at the edge 150	None	None	8	R 25% of slab thickness	Butt joint	R depending on joint filling	R 1.5 times width	(i) 16 (ii) 800 (iii) 1500	R Bituminous filling material according to German DIN requirements or plastic rubber inserts

Reinforcement / Armatures / Bewehrung		Cement / Ciment / Zement		
Specified or permitted Imposées ou permises Vorgeschrieben oder gestattet	kg/m² or % for each direction for various slab thicknesses Poids en kg/m² ou pourcentage dans chaque direction pour différentes épaisseurs de dalle kg/m² oder % für jede Richtung für verschiedene Plattendicken	Type used Désignation Benutzte Zementart	Restrictions governing use Prescriptions particulières Besondere Bedingungen	Max. temp. at time of use Température maximale au moment de l'emploi Höchsttemperatur beim Einbau °C
58	59	60	61	62
		Ordinary Portland Cement 275	R Blaine $\leqq$ 3300 cm³/g 28 days flex. $>$ 60 kp/cm²	N
Only in continuously reinforced concrete	A Longitudinal reinforcement 0.7-1.0%	N	None	N
Generally not used	A	Special cement for roads	R $C_3A < 8\%$ in clinker Blaine 2250-3700 cm²/g	R 60°C
		Ordinary Portland Cement		
Generally not used	None	R Ordinary Portland cement with (sometimes) additives Portland 325	R $C_3A < 8\%$	N
P Steel fabric (Oblong mesh) Steel bar (Deformed bars)	M & MR: Total weight not less than 4.34 kg/m² SR: total weight not less than 3.41 kg/m²	Ordinary Portland cement or Portland Blast Furnace	Each consignment to be kept separately in a silo or in a dry waterproof shed and to be used in order of delivery	N
R	Use of continuous reinforcement is under discussion	Ordinary Portland or Blast Furnace Slag cement	Initial setting time $>$ 2 hours	N
E	Total weight of reinforcement M MR N 2.0 kg/m²	Portland 325 (R) Portland 425 (E)	R Initial setting time $>$ 2 hours 1 hour at 30°C	R 70
P (M and MR) R (Continuously reinforced concrete)	R (i) slab length up to 8 m, min. 2-25 kg/cm² (ii) from 8-12 m, min. 2.5-3.0 kg/cm² (iii) cont. reinforced, 0.6-0.7% long	R Portland cement with or without additives blast furnace or pozzolonir, 350	R Max. 10% C_3A initial setting time >2 hours 1 hour at 30°C	P 70
		Ordinary Portland cement	None	N
A	N ~ 1.00 kg/m²	Ordinary Portland cement		
Not specified or permitted	R M: $\leqq$ 5 m: 3 kg/m²; $>$ 7.5 m: 3 kg/m² MR & SR: 2 kg/m²; 3 kg/m²	R Z 350	R Cement has to meet the German DIN 1164 and the requirements according to ARS Circular 2/1971	N

Concrete / Béton / Beton				
Strength specified Résistances exigées Vorgeschriebene Festigkeit				
Compressive A la compression Druck kg/cm^2	Flexural A la flexion Biegezug kg/cm^2	Type of specimen and test method Type des éprouvettes et méthode d'essai Prüfkörper und Prüfverfahren	Frequency of testing Fréquence des essais Häufigkeit der Prüfungen	Max. amount of mixing water Dosage maximal en eau Maximale Anmachwassermenge
63	64	65	66	67
R Not less than 400 at 28 days (350 lower layer)	Not less than 55 at 28 days	R Cubes 20 cm Beam 12 x 12 x 36 cm	R 6000 m^2	E W/C = 0.42-0.47
N	N	R Cores cut: 100 cm^2 section and 10 cm high compression	R One core for 1000 m^2	N
N	R Indirect tensile test. 45 at 28 days (M) (MR) 40 at 28 days (SR)	R Beams 15 × 15 × 70 cm stored in water at 20°C + 3°C third point loading	R 600 m^3 (M) 300 m^3 (MR) 200 m^3 (SR)	R W/C = max. 0.45 (M) (MR) 0.50 (SR)
> 400 at 28 days	N	Cylinders 30 cm × 15 cm diameter compressive strength	Every 1000 m^2	W/C ≦ 0.4
	Rc > 45 at 28 days	Rc = R (1-KV) R = mean of N results K = coefficient function of N results V = coefficient of variations of this series	From twice per week to 3 times per day on 3 specimens	E Amount agreed
N	R Indirect tensile test. Average not less than 18.5 at 7 days and 23 at 28 days	R Cylinders (15 cm diameter) Indirect tensile test	R At least one pair of cylinders for each 75 m run of carriageway	R W/C = 0.55
Not less than 500 at 56 days compressive strength test used on top layer in two layer system	N Indirect tensile test used on bottom layer in two layer system	Cores 10-15 cm diameter ($\frac{l}{d}$ = 1)	1 core for 1000-5000 m^2	W/C ≦ 0.45
R 300 at 7 days 400 at 28 days	R 40 at 7 days 50 at 28 days	Compressive: cubes Flexural: beams Splitting: cylinders	For > 200 m^3 Compression 12 specimens per day. Flexural 9 specimens per day. Splitting 3 specimens per day	W/C ~ 0.5
N	R M and MR 45 or 40 SR 40 or 35	R Beams 15 × 15 × 60 cm Third point loading	R Min. 3 series of 2 beams per day (M, MR) Min. 2 series of 2 beams per day (SR)	R W/C Max. 0.55
Specimens (cubes or cylinders) are required but no minimum strength is specified	R ≧ 43 at 28 days	R Beams 10 x 15 x 80 cm Third point loading. Cubes 15 x 15 x 15 cm Cylinders ⌀ 15 x 30 cm	R At least one series of 3 beams for every volume unit of 250 m^3 concrete	N
R Top layer >380 at 28 days Bottom layer >380 at 28 days	R Top layer >52 at 28 days Bottom layer >46 at 28 days	R Beams 12 x 12 x 36 cm or Cylinders ⌀ 15	R Every 2000 m^2	N Top layer W/C ≧ 0.45 Bottom layer ≧ 0.42
R 400 at 28 days	R 55 at 28 days	R Compressive: cubes 20 x 20 x 20 cm Flexural: beams 10 x 15 x 70 cm	R Compressive: at work start and every 1000 m^2 Flexural: preliminary test at commencement	N Usually W/C ≦ 0.45

Concrete / Béton / Beton

Minimum cement content Dosage minimal en ciment Mindestzementgehalt Kg/m^3	Consistency (test method and frequency) Consistance (méthode et fréquence d'essai) Konsistenz (Prüfverfahren und -häufigkeit)	Basic proportions specified or used (materials measured by weight unless otherwise noted) Composition théorique prescrite ou habituelle (en poids sauf indication contraire) Grundsätzliches Mischungsverhältnis vorgeschrieben oder gebräuchlich (nach Gewicht, wenn nicht anders angegeben)	Air entrained concrete pavement / Revêtement en béton aéré / Fahrbahndecke aus Luftporenbeton Whether specified Prescrit ou non Vorgeschrieben oder nicht	% air required (maximum and minimum) Pourcentage d'air exigé Vorgeschriebener LP-Gehalt in %	Method of determining air content and frequency Méthode de détermination de la teneur en air et fréquence des essais Verfahren und Häufigkeit der LP-Bestimmung
68	69	70	71	72	73
E Upper layer 370 Lower layer 320	N	E High amount of coarse aggregate (gap graded mix) at surface to give high abrasion resistance against studded tyres	R Always	R 3.5-5.0	R Air meter (pressure method) 3/day at start of work micrscopic examination of hardened concrete
R 350	N	N	N	N	
R 320	R Slump test VEBE every 600 m^3 (M) 300 m^3 (MR) 200 m^3 (SR)	R Sieve (mm) / % Passing: 0.25 / 3-9; 0.50 / 8-18; 1 / 19-26; 2 / 20-34; 4 / 28-42; 8 / 37-51; 15 / 51-72; 32 / 90-100; 45 / 100	R Always	R 3.5-6.5	Air meter - pressure method every 2 hours (M) & (MR) 3 times a day (SR)
335	N VEBE	Sand 35% 5-8 mm 30% 8-18 mm 35%	R	5 ± 1	Air meter (pressure method) per 1000 m^2
R 300	R Slump test every 200 m^3 and at least every 2 hours	N Based on preliminary tests	R	R 3-6	R Air meter Every 200 m^3 and at least every 2 hours
R 280	R Compacting factor Slump (P) Frequency (N)	N	R Yes for the concrete in at least the top 50 mm	R 4.5 ± 1.5	R Pressure type air meter at least 6 times per day
375 if two layers 300 in bottom	Slump test daily: 1-3 cm Walz density test	35-40% sand (max. 4 mm) 65-60% gravel	N	N	N
One layer 330	Slump test every 120 m^3 or every 2 hours	Cement: 300-350 kg/m^3	R	3-6	Air meter apparatus or equivalent Every 120 m^3 or every 2 hours
R 300	R As used in laboratory if slump test: 2-6 cm	N Based on preliminary tests	R Only in frost areas otherwise E	R 4-6	Air meter (UNE 7141)
R 325	The Swedish VEBE equipment (N) At least once a day (R)	N Common proportions: Cement: Fine Aggr.: Coarse Aggr. 1: 2.4-2.8: 3-3.4 by weight	R	R 4-6	By the pressure method at least once a day (R)
N Top layer: 350 Bottom layer: 250	N VEBE	Laboratory design (see columns 68 to 83)	R For Top layer	4-6	Pressure each 500 m^2 M - each 2500 m^2 microscopic analysis TAS
N Usually 330-350		R According to DIN 1045 to be laid down by preliminary tests	R	R Min. 3.5	R Method of pressure compensation Frequency once per hour

Fine Aggregate / Agrégat fin / Feine Zuschlagstoffe

If specified, grading: per cent by weight passing each sieve La granulométrie si celle-ci est prescrite en % passant à travers chaque tamis Wenn vorgeschrieben, Kornzusammensetzung: Durchgang durch Siebe in Gewichts-%								Notes on fine aggregate, types, frequency of testing, etc. Notes relatives aux granulats, nature, fréquence des essais, etc. Bemerkungen zu feinen Zuschlagstoffen Art, Häufigkeit der Prüfung usw.
74	75	76	77	78	79	80	81	82
N	N	N	N	N	N	N	N	N-E One grading test per day
R ASTM No. 4 100	R No. 8 80-100	R No. 16 60-100	R No. 30 20-80	R No. 50 0-35	R No. 100 0-10	R No. 200 < 2	R Sand equivalent > 80	R Organic matter < 0.5% $CaCO_3$ Content < 50%
N	N	N	N	N	N	N	N	R Sand equivalent 1000 m² (M)
N	N	N	N	N	N	N	N	Lime content in material less than 4 mm must not exceed 10% (R)
R 5 mm 100-95	R 2.5 mm 90-70	R 1.25 mm 80-45	R 0.63 mm 55-28	R 0.315 mm 30-10	R 0.16 mm 10-2	R Modulus of fineness must not vary by more than ± 0.2	Sand equivalent > 75	R Every 1000 T - two grading tests 5 sand equivalent tests 2 tests for lime $CaCO_3$ < 30%
N	N	N	N	N	N	N	N	Natural occuring material except limestone Frequency of testing N
4 mm 90-100	1 mm 40-80	25 mm 50-20	63 mm 2					N
5 mm 100	2 mm 90-100	0.4 mm 40-65	0.18 mm 15-35	0.075 mm 0-5			Sand equivalent > 80	Grading plus sand equivalent 2 tests per day moisture content every 360 m³
R 5 UNE 90-100	R 2.5 UNE 65-90	R 1.25 UNE 45-75	R 0.63 UNE 27-55	R 0.32 UNE 10-30	R 0.16 UNE 2-10	R	R Fineness modulus max variation 5%	R
4.00 mm 100	2.00 mm 92-66	1.00 mm 65-35	0.5 mm 42-18	0.25 mm 26-5	0.125 mm 11-0	0.075 mm 2-0		Max. slope of the particle distribution curve is specified. Natural material (not crused) is preferred. No lumps of clay, pieces of wood, etc. Presence of organic impurities is controled by the sodium hydr. test
Fuller graduation	Fuller graduation	Fuller graduation	Fuller graduation	Fuller graduation	Fuller graduation	Fuller graduation	Fuller graduation	Sieving every week
N DIN 1045	N DIN 1045	N DIN 1045	N DIN 1045	N DIN 1045	N DIN 1045	N DIN 1045	N DIN 1045	R Cement content and aggregate type 0-0.25 Min. 350 kg/m³ Max. 400 kg/m³

Coarse aggregate / Gros agrégat / Grobe Zuschlagstoffe

Separate sizes used Différentes dimensions utilisées Gebräuchliche getrennte Korngruppen mm	If specified, grading: per cent by weight passing each sieve La granulométrie si celle-ci est prescrite en % passant à travers chaque tamis Wenn vorgeschrieben, Kornzusammensetzung: Durchgang durch Siebe in Gewichts-%								Notes on coarse aggregate, types, frequency of testing, etc. Notes relatives aux granulats, nature, fréquence des essais, etc. Bemerkungen zu groben Zuschlagstoffen, Art, Häufigkeit der Prüfungen usw.
83	84	85	86	87	88	89	90	91	92
R 0.6/1.0 1/4 4/8 8/25-32	N	N	N	N	N	N	N	N	High strength and abrasion resistance required for upper layer
N	N	N	N	N	N	N	N	N	R $CaCO_3$ content < 50% Natural crushed stone
8-16 16-32	N	N	N	N	N	N	N	N	: Soft aggr. max. 3% Los Angeles max. 35
0-4 mm 5-8 mm 8-18 mm	N	N	N	N	N	N	N	N	N Crushed granite
E 5/20 20/40									R Los Angeles < 20 Every 1000 T 2 grading tests 2 tests of N. Los Angeles < 15 if possible
Normally: (i) 40-20 (ii) 20-10 (iii) 10-5 Sometimes (ii) and (iii) only	N	N	N	N	N	N	N	N	E Natural occuring gravel, crushed rock, or crushed air-cooled blast furnace slag to 85 882
	31.5 mm 90-100	16 mm 40-70	4 mm 0-10	66 µm < 1					River gravel
≧ 3 separate sizes or E	Fuller grading								Clay lumps 0.25% Silt and clay 1% Wood, soft rock 2%
R Min. 2 separate sizes	R 50 mm 100	N	N	N	N	N	N	N	R Los Angeles 35
R Max. 25-30 Min. 4	N	N	N	N	N	N	N	N	Gravel (fully rounded particles), crushed gravel or crushed rock (with most cubic shpae) are used content of silt and clay controlled if necessary
Top layer 0 - 3 3 - 6 6 - 16 16 - 25	Fuller graduation	Fuller graduation	Fuller graduation	Fuller graduation	Fuller graduation	Fuller graduation	Fuller graduation	Fuller graduation	Sieving every week
R 0/2 2/8 > 8	R DIN 1045	R DIN 1045	R DIN 1045	R DIN 1045	R DIN 1045	R DIN 1045	R DIN 1045	R DIN 1045	Testing: 1 x per day Aggregates must meet the German Regulations according to DIN 4226

Concrete mixing / Fabrication du béton / Betonmischung					
Central mixing Malaxage en centrale Zentralmischanlage		Truck mixing Malaxage en camion Transportbeton			
Specified or permitted Prescrit ou autorisé Vorgeschrieben oder gestattet	If specified, mixing time (seconds) and type of mixer Durée du malaxage (en secondes) et type de malaxeurs si ceux-ci sont prescrits Wenn vorgeschrieben, Mischzeit (sec) und Art des Mischers	Specified or permitted Prescrit ou autorisé Vorgeschrieben oder gestattet	Revolutions specified (minimum and maximum) (RPM) Nombre de tours prescrit (tours par minute) Vorgeschriebene Umdrehungszahl für Mischen in U/min.	Agitation specified (minimum and maximum) (RPM) Agitation prescrite Vorgeschriebene Umdrehungszahl für Rühren in U/min.	Maximum time between water addition and discharge (min) Durée maximale entre l'addition d'eau et le déchargement du béton Höchstzeit zwischen Wasserzugabe und Entleerung
93	94	95	96	97	98
R	N	N	N	N	N
N	N	N	N	N	N
R	R M (MR)	N	N	N	N
R	Usually 90 sec	Not used			
Generally specified	E Generally 45 sec.	Not used	Not used	R 2 to 3 revolutions per minute if truck mixer used	Max. time for transport in truck mixer 1-1½ hours
OC atch type or continuous mixed	N	P	Min. 7 Max. N	N	N
R	Min. 60 Ordinary type and forced mixing type	N			
R	$\geqq$ 60	N			
R	E	X (M, MR) P (SR)	P (SR) Min. 4 Max. 16	P (SR) Min. 6	P (SR) Max. 1½ hours
R	R 60 Drum mixers (4-5m³)	Not used			
R	R 60	Not used	Not used	Not used	Not used
EN	Mixing time usually: 90 Types of mixer: N	PE	4 to 12	2 to 6	45 min.

Paving and finishing / Mise en place et surfaçage / Einbau und Fertigbehandlung				
Placing temperature minimum and/or maximum Température au moment de la mise en place (maximum ou minimum) Einbautemperatur min. und/oder max.				
Air temperature Température de l'air Lufttemperatur °C	Concrete temperature Température du béton Betontemperatur °C	Construction widths permitted Largeur permise des bandes placées simultanément Zulässige Einbaubreiten	Is slip-form paver used or permitted by specification? La machine à coffrages glissants est-elle utilisée ou permise par les spécifications? Wird Gleitschalungsfertiger benutzt oder in Ausschreibung gestattet?	Type of final finish or texture Nature de la finition ou de la texture de surface Art der Oberflächenbehandlung bzw. -textur
99	100	101	102	103
R: + 5 P: − 3	R Min. + 5 Max. + 30	N	Yes but not yet used	N
N	N	N	Yes	Grooves-spacing 15-30 mm
N	R Summer: max. + 30	Max. 11	Yes	N (transverse brooming)
Min. + 5	N	3-lane carriageways (3 x 3.75 m) may be constructed in one operation	(OC) Practically the only method used	(R) Grooved or exposed aggregate
N Generally > 5	N Generally > 30	OC No restriction Max. used 11 m	OCP Practically the only method used	E Jute cloth and transverse brushing
R Min. 3	Max. + 30	N 3-lane carriageways (11 m wide) may be constructed in one operation	OC Permitted	R Transverse brushed with wire broom or irregularly spaced grooves formed in wet concrete
Min. 4 Max. N	N	N	Not yet used (the small type slip-form paver has been used for constructing farm roads)	Transverse brushing or grooving
Min. 2 2-5 Mixing water heated (R) Max. E	N	N	Yes	Transverse brushing
R Min. 0 Max. 40 or specifial protection (E)	N	N	Yes	R Longitudinal or transverse brushing Transverse groove 15-7 mm at variable distance 15-35 mm
R ≧ + 5 (if water or aggregate is not heated)	Not specified	R 8.0 m	R	N Transverse blooming (horse hair brooms) Aluminum pipe and jute drag after slip-form paver
N	> N	8.00 m	Used only for rural roads not banned from the construction of other roads	Brushing or finisher texture
Min.: + 5 P: − 3	Min. + 5 Max.: + 30	E Usually up to 9 m	E	R Transverse brushing

Paving and Finishing / Mise en Place et Surfaçage / Einbau und Fertigbehandlung

estrictions on time for finishing imite de temps pour l'exécution des travaux de surfaçage Zeitbeschränkung für die Fertigbehandlung	Surface Tolerance / Tolérance de surface / Oberflächentoleranzen Maximum variation permitted Ecart maximal autorisé Höchstzulässige Abweichung	Surface Tolerance / Tolérance de surface / Oberflächentoleranzen Method of adjustment of levels, or financial penalty Correction des écarts, ou pénalités Ausbesserungsverfahren für die Ebenheit, bzw. Vertragsstrafen	Skidding resistance requirements Prescriptions relatives à la résistance au dérapage Griffigkeitsvorschriften
104	105	106	107
R Upper layer must be compacted within 1-2 hours and 3 hours after compaction (placing) of lower layer	R 3 mm under 4 m straight edge	R Grinding, removal or penalty	N
N	R 4 mm under 3 m straight edge control by "Viagraph„ or "bump integrator„	R > 4 mm and < 7.5 mm: correction or financial penalty > 7.5 mm: correction	R 0.50 at 80 km/h measured by "Stradograph„
N	R Design velocity — Viagraf — Tolerance under the 4 m straight edge Vd ≧ 200 km/h — max 5 — 3 mm 150 ≦ Vd < 200 — max 6 — 4 mm 100 ≦ Vd < 100 — max 8 — 5 mm 50 = Vd < 100 — max 10 — 6 mm Vd < 50 — max 12 — 7mm	R Grinding or replacement	R Evaluation of the skid resistance by the standard CSN 73-6195
Within 1 ½ hours of mixing	Surface irregularities per 100 m (5 m straight edge) mm — Number 7.5 — 0 6 — max. 1 5 — max. 3 3 — max. 9	R Grinding or replacement	New specifications under consideration (stradograph and tentative depth)
None	R < 3 mm under a 3 m straight edge "Viagraph„ coefficient < 3	R Grinding or replacement	R Middle size of sand > 1 mm In some cases > 2 mm
R Within 3 hours of mixing. Reduced to 2 hours when concrete temperature is 25-30	R ± 6 mm from true pavement surface. Number of surface irregularities exceed 4 mm not to be greater than 20 per 300 m. Number of surface irregularities exceeding 7 mm not to be greater than 2 per 300 m. None to be greater than 10 mm.	High places ground down. Low spots cut out to a depth of not less than 25 mm and replaced	R Average brushed texture depth to be not less than 0.75 mm Average depth and width of grove to be divided for each
As soon as possible	3 mm under 3 m straight edge	> 3 mm financial penalty > 5 mm financial penalty and removal of unevenness	> 0.56 at 50 km/h (86% slip)
N	3 mm under 3 m straight edge	Both	N
N	R 3 mm under 3 m straight edge	R Grinding	N
None	R ≦ 6 mm depressions under straight edge of 5 m length in longitudinal direction	N (i) Grinding of surface ridges (ii) Financial penalty	None
N < 1 hour	3 mm under 4 m straight edge	Grind	SRT > 50
In dry warm weather 1 hour; in wet cool weather 2 hours after placing the concrete	R 3 mm under 4 m straight edge	Grinding or financial penalty	N

Curing / Cure du béton / Nachbehandlung				
Initial method Cure initiale Erste Nachbehandlung			Final method Cure finale Endgültige Nachbehandlung	
Is initial curing specified? Une cure initiale est-elle imposée? Ist eine erste Nachbehandlung vorgeschrieben?	Type normally used Prescriptions habituelles Gebräuchliches Verfahren	Number of hours Nombre d'heures Zahl der Stunden	Type normally used Prescriptions habituelles Gebräuchliches Verfahren	Number of days Nombre de jours Zahl der Tage
108	109	110	111	112
	Protection against sun and rain by tents		R Spraying of curing compound	R Until opening to traffic
		N	(i) curing compound for continuously reinforced concrete (R) (ii) N for plain concrete	N
N	N	N	Spraying of curing compound	min. 7
N			Curing compound	
R	OC As for final method		E Curing compound is permitted method	R 3
R	As for final method		R Spraying with aluminised curing compound immediately after texturing	R June to August 14 September to May 20
R	Wet Burlap Curing compounds		Curing compound sometimes wet sand	N
N			Curing compound immediately after brushing	Min. 7
R	OC Protection from rain quick drying frost E tents in humid areas	N	R Curing compound wt mats and waterproof membranes are also permitted	E Min. 7
N			N Curing compound	
R	Protection by tents	5	Curing compound	Min. 3
R	R Protection from rain, frost and heat by tents	4 to 8 depending on method and temperature	R Covering with mats, keep wet or use curing compound	R 7

Test Cores / Carottes / Bohrkernentnahme				Opening to traffic	Official specifications Prescriptions officielles Behördliche Bestimmungen	
To check Objet des vérifications Zur Überprüfung		Penalty Pénalité Vertragsstrafen				
Strength Résistance Festigkeit	Thickness Epaisseur Dicke	For deficient strength Pour insuffisance de résistance Für Unterfestigkeit	For deficient thickness Pour insuffisance d'épaisseur Für mangelnde Dicke	Délai de mise en service Verkehrsübergabe	Authority issuing Administration compétente Für die Herausgabe zuständige Behörde (oder Stelle)	Year of latest version and date of supplements Date de la dernière édition et date des suppléments Jahr der letzten Ausgabe und Daten der Nachträge
113	114	115	116	117	118	119
		R Penalty or removal of slab		When flexural strength at least 44 kg/cm²	Austrian Road Research Board	1976
R Cores every 1000 m² (but min. 10 N° max. 50 N°) Compressive strength at 56 days > 600 kg/cm²	R On cores taken as in previous column	R Financial penalty or removal of slab	R Financial penalty or removal of slab	N Generally 14 to 21 days after concreting	Ministry of Public Works Administration for Roads	1972
N	R (M) + 16 mm Statistical value (95% cores) (MR) + 17 mm (95% cores) (SR) + 19 mm (95% cores)	N	N	N	Office for Standards and Measurement (Prague)	1974 Standard CSN 73-6171
N	To be measured in the field in fresh concrete	(R) Financial penalty or removal of slab	R Financial penalty or removal of slab	28 days	Ministry of Public Works	1968 Revision 1971 Revision 1976
R Following checks during concreting	R from cores	R Financial penalty or removal of slab	R Financial penalty or removal of slab		Ministère de l'Equipement «Cahier des Prescriptions Communes» Fascicule 28	New Fascicule 28 prepared 1972
N	E from cores	N	N	20 days, 14 days during months of June to August inclusive	Department of the Environment	Manual of Standard Highway Designs Road Note No. 29 (3rd) Specification for Road & Bridge Works 1976 D. of E. Technical Memoranda
Compressive strength of 40 cores 15 cm diam. at 56 days > 500 kg/cm²	Sometimes on cores (at any rate during construction)			At least 21 days after concreting	Ministry for Roads and Waterways	1972
R Not less than 90% specified	R Not more than 2-5 mm under specified thickness	80% financial penalty or removal of slab	For 10-20 mm 2% financial penalty For > 20 mm removal	At least 12 days after concreting	Azienda Nazionale Strada (ANAS) Consiglio Nazionale delle Ricerche (CNR)	ANAS being revised CNR $ 7/11/72
R Indirect tensile test at 56 days	R From cores (10 cm)	P Financial penalty or removal of slab	N	R Min. 7 days or when 80% specified strength reached	Ministry of Public Works	1975
As a rule not specified	As a rule not specified			R ≤ 10 days (if the flexural strength ≤ 35 kg/cm²)	National Swedish Road Board	1976 Preliminary
R	R	N	N	>14 days	S.N.V. Specifications	1976
R 1 core for 1000 m²	R 1 core for 1000 m²	R See TV Beton 72 e.g. 0.1% penalty for 1% deficiency 10% penalty for 10% deficiency	R See TV Beton 72 e.g. 30% penalty for 10% deficiency	R When 90% specified compressive strength reached	Bundesministerium für Verkehr	T.V. 1972 Beton Techn. Vorschriften und Richtlinien fur den Bau von Fahrbahndecken Addenda 1975