OVERSEAS ROAD NOTE 31

A GUIDE TO THE STRUCTURAL DESIGN OF BITUMEN-SURFACED ROADS IN TROPICAL AND SUB-TROPICAL COUNTRIES

- Parent fines are the fines developed during crushing of rocks. These are usually 5 mm or less in size. These should be used to fill the voids of aggregates.
- Macadam developed the design procedure for the construction of pavements.
- Particle size is 37.5 mm or 50 mm in Dry Bound Macadam and Water Bound Macadam.

- In Dry Bound Macadam, vibrations are used to fill the parent fines into the voids of gravels.
- In Water Bound Macadam, water is used to fill the parent fines into the voids of gravels. This technique gives better results normally to fill the voids. But if the subgrade is clayey then water will reduce its strength.

- **CBR > 80% for Base Material**
- **If CBR > 30% for subgrade, then Sub-base is not required**
- **If subgrade has CBR < 4%, then use Capping Layer**
- **There are two types of Surface Dressings**
    1. **Single Surface Dressing**
    2. **Double Surface Dressing**

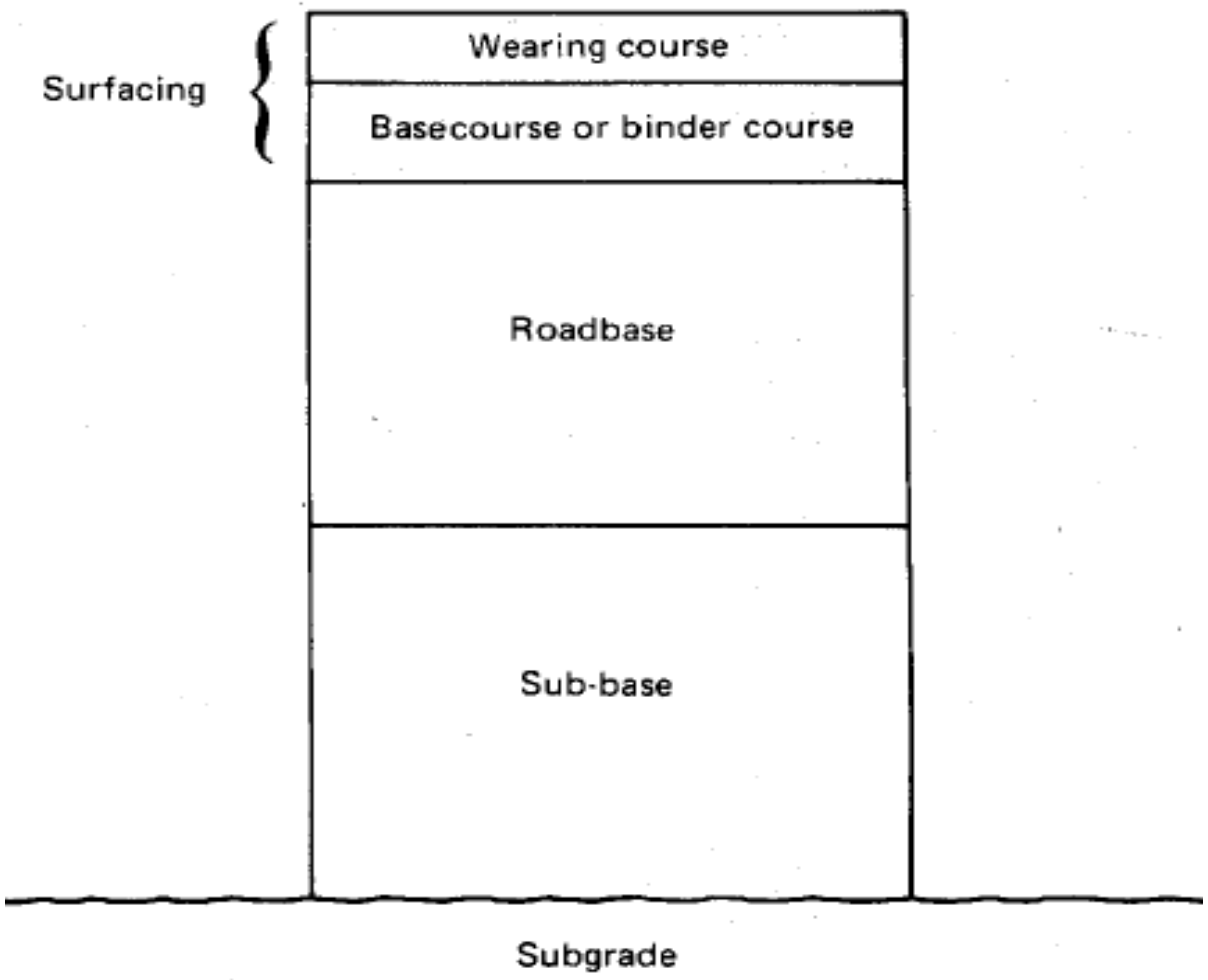
Single surface dressings are normally adequate when applied to a bituminous layer. To be satisfactory for non-bituminous surfacings, the quality of a single seal must be very high and subsequent minor maintenance must be carried out promptly when required.

It is recommended that double surface dressings are always used on non-bituminous layers. The quality of a double surface dressing will be greatly enhanced if traffic is allowed to run on the first dressing for a minimum period of 2-3 weeks (and preferably longer) before the second dressing is applied. This allows the chippings of the first dressing to adopt a stable interlocking mosaic which provides a firm foundation for the second dressing. If the trafficking results in the contamination of the first dressing with mud or soil, this should be thoroughly cleaned off before the second dressing is applied.

Sand may sometimes be used as an alternative to chippings for the second dressing. Although this cannot contribute to the overall thickness of the surfacing, the combination of binder and sand provides a useful grouting medium for the chippings of the first seal and helps to hold them in place more firmly if they are poorly shaped. A slurry seal may also be used for the same purpose.

Flexible bituminous surfacing

It is essential that the thin bituminous surfacings (50mm) recommended for structures described in Charts 3,4 and 7 of the structural catalogue are flexible. This is particularly important for surfacings laid on granular roadbases. Mixes which are designed to have good durability rather than high stability are flexible and are likely to have `sand' and bitumen contents at the higher end of the permitted ranges. In areas where the production of sand-sized material is expensive and where there is no choice but to use higher stability mixes, additional stiffening through the ageing and embrittlement of the bitumen must be prevented by applying a surface dressing.



Nomenclature

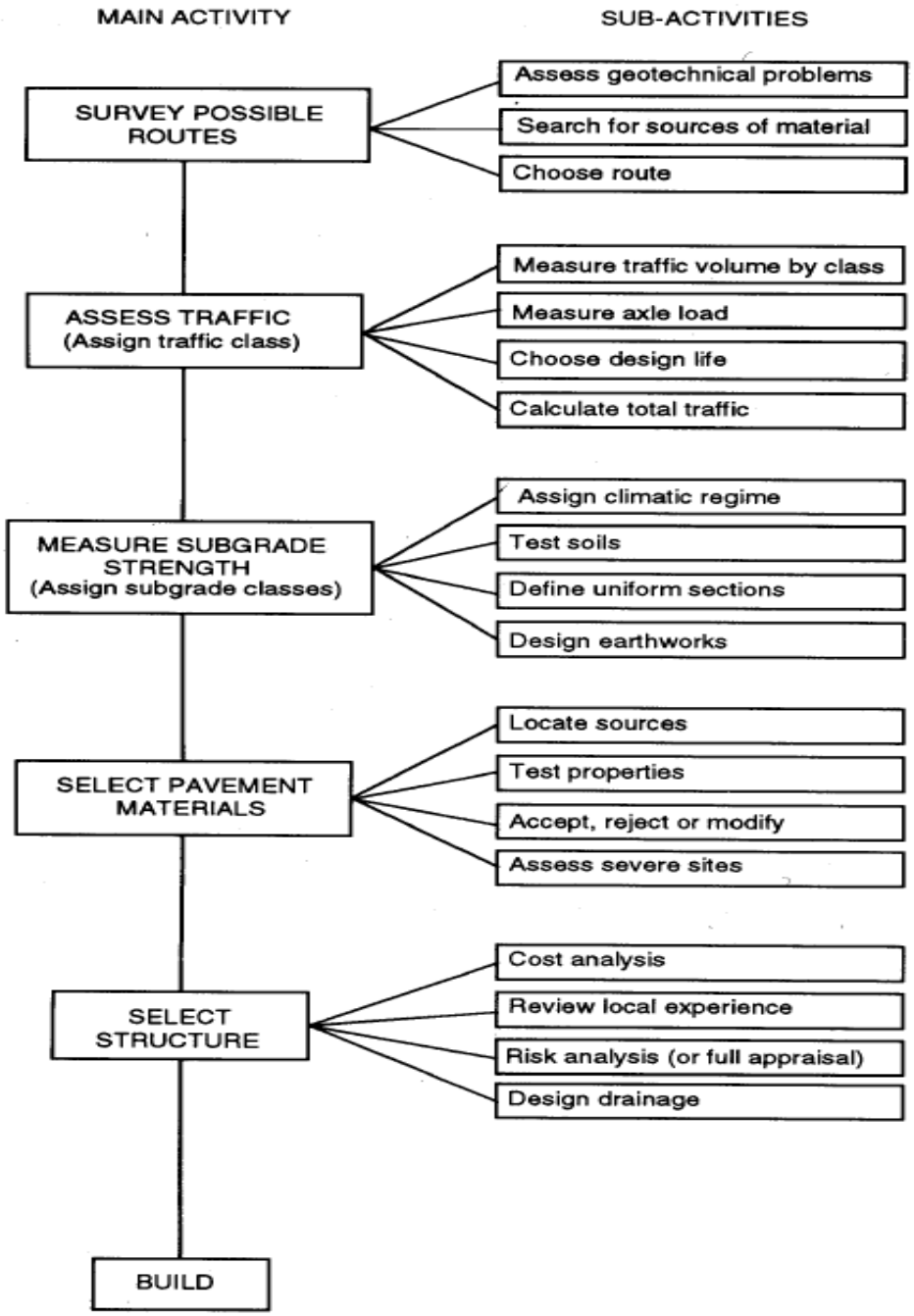
The Design Process

There are three main steps to be followed in designing a new road pavement These are:

(i) estimating the amount of traffic and the cumulative number of equivalent standard axles that will use the road over the selected design life;

(ii) assessing the strength of the subgrade soil over which the road is to be built;

(iii) selecting the most economical combination of pavement materials and layer thicknesses that will provide satisfactory service over the design life of the pavement (It is usually necessary to assume that an appropriate level of maintenance is also carried out).


MAIN ACTIVITY
SUB-ACTIVITIES
SURVEY POSSIBLE ROUTES
Assess geotechnical problems
Search for sources of material
Choose route
ASSESS TRAFFIC (Assign traffic class)
Measure traffic volume by class
Measure axle load
Choose design life
Calculate total traffic
MEASURE SUBGRADE STRENGTH (Assign subgrade classes)
Assign climatic regime
Test soils
Define uniform sections
Design earthworks
SELECT PAVEMENT MATERIALS
Locate sources
Test properties
Accept, reject or modify
Assess severe sites
SELECT STRUCTURE
Cost analysis
Review local experience
Risk analysis (or full appraisal)
Design drainage
BUILD

Equivalence factors for different axle loads

Wheel load (single & dual) (10^3 kg)	Axle load (10^3 kg)	Equivalence factor
1.5	3.0	0.01
2.0	4.0	0.04
2.5	5.0	0.11
3.0	6.0	0.25
3.5	7.0	0.50
4.0	8.0	0.91
4.5	9.0	1.55
5.0	10.0	2.50
5.5	11.0	3.83
6.0	12.0	5.67
6.5	13.0	8.13
7.0	14.0	11.3
7.5	15.0	15.5
8.0	16.0	20.7
8.5	17.0	27.2
9.0	18.0	35.2
9.5	19.0	44.9
10.0	20.0	56.5

$$\text{Equivalence factor} = \left(\frac{\text{Axle load (kg)}}{8160}\right)^{4.5}$$

Traffic classes

Traffic classes	Range (10^6 esa)
T1	< 0.3
T2	0.3 - 0.7
T3	0.7 - 1.5
T4	1.5 - 3.0
T5	3.0 - 6.0
T6	6.0 - 10
T7	10 - 17
T8	17 - 30

Subgrade strength classes

Class	Range (CBR %)
S1	2
S2	3 - 4
S3	5 - 7
S4	8 - 14
S5	15 - 29
S6	30

Properties of unbound materials

Code	Description	Summary of specification
GB1,A	Fresh, crushed rock	Dense graded, unweathered crushed stone, non-plastic parent fines
GB1,B	Crushed rock, gravel or boulders	Dense grading, PI < 6, soil or parent fines
GB2,A	Dry-bound macadam	Aggregate properties as for GB1,B (see text), PI < 6
GB2,B	Water-bound macadam	Aggregate properties as for GB1,B (see text), PI < 6
GB3	Natural coarsely graded granular material including processed and modified gravels	Dense grading, PI < 6 CBR after soaking > 80
GS	Natural gravel	CBR after soaking > 30
GC	Gravel or gravel-soil	Dense graded, CBR after soaking > 15

Notes
1. These specifications are sometimes modified according to site conditions, material type and principal use (see text).
2. GB = Granular roadbase, GS = Granular sub-base, GC = Granular capping layer.

Recommended plasticity characteristics for granular sub-bases (GS)

Climate	Liquid Limit	Plasticity Index	Linear Shrinkage
Moist tropical and wet tropical	<35	<6	<3
Seasonally wet tropical	<45	<12	<6
Arid and semi-arid	<55	<20	<10

Properties of cement and lime-stabilised materials

Code	Description	Unconfined compressive strength* (MPa)
CB1	Stabilised roadbase	3.0 - 6.0
CB2	Stabilised roadbase	1.5 - 3.0
CS	Stabilised sub-base	0.75 - 1.5

* Strength tests on 150 mm cubes (see Section 7.4)

Guide to the type of stabilisation likely to be effective

Type of stabilisation	Soil properties					
	More than 25% passing the 0.075 mm sieve			*Less than 25% passing the 0.075 mm sieve*		
	PI≤10	10<PI≤20	PI>20	PI≤6 PP≤60	PI≤10	PI > 10
Cement	Yes	Yes	*	Yes	Yes	Yes
Lime	*	Yes	Yes	No	*	Yes
Lime-Pozzolan	Yes	*	No	Yes	Yes	*

Notes. 1. * Indicates that the agent will have marginal effectiveness
2. PP = Plasticity Product (see Chapter 6).

PP = PI x (percentage passing the 0.075 mm sieve)

Summary of material requirements for the design charts

CHART NO	SURFACING	ROADBASE
1	Double surface dressing	T1-T4 use GB1,GB2 or GB3 T5 use GB1,A or GB1,B T6 must be GB1,A
2	Double surface dressing	T1-T4 use GB1, GB2 or GB3 T5 use GB1 T6,T7,T8 use GB1,A
3	'Flexible' asphalt	T1-T4 use GB1 or GB2 T5 use GB1 T6 use GB1,A
4	'Flexible' asphalt	T1-T4 use GB1 or GB2 T5 use GB1 T6-T8 use GB1,A
5	Wearing course and basecourse	GB1,A
6	Wearing course and basecourse	GB1 or GB2
7	High quality single seal or double seal for T4. 'Flexible' asphalt for T5-T8	RB1, RB2 or RB3
8	Double surface dressing	CB1, CB2

RB1 **Bitumen Macadam Roadbase** ***Bitumen Content 4.0±0.5***
RB2 & RB3 **Rolled Asphalt Roadbase** ***Bitumen Content 5.7±0.6***

KEY TO STRUCTURAL CATALOGUE

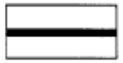
Traffic classes
(10⁶ esa)

T1 = < 0.3
T2 = 0.3 - 0.7
T3 = 0.7 - 1.5
T4 = 1.5 - 3.0
T5 = 3.0 - 6.0
T6 = 6.0 - 10
T7 = 10 - 17
T8 = 17 - 30

Subgrade strength classes
(CBR%)

S1 = 2
S2 = 3 , 4
S3 = 5 - 7
S4 = 8 - 14
S5 = 15 - 29
S6 = 30+

Material Definitions

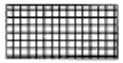

Double surface dressing


Flexible bituminous surface


Bituminous surface
(Usually a wearing course, WC, and a basecourse, BC)

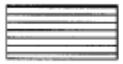

Bituminous roadbase, RB

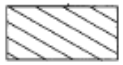

Granular roadbase, GB1 - GB3


Granular sub-base, GS


Granular capping layer or selected subgrade fill, GC


Cement or lime-stabilised roadbase 1, CB1


Cement or lime-stabilised roadbase 2, CB2


Cement or lime-stabilised sub-base, CS

KEY TO STRUCTURAL CATALOGUE

Traffic classes

(10^6 esa)

T1 = < 0.3
T2 = 0.3 - 0.7
T3 = 0.7 - 1.5
T4 = 1.5 - 3.0
T5 = 3.0 - 6.0
T6 = 6.0 - 10
T7 = 10 - 17
T8 = 17 - 30

Subgrade strength classes

(CBR%)

S1 = 2
S2 = 3 , 4
S3 = 5 - 7
S4 = 8 - 14
S5 = 15 - 29
S6 = 30+

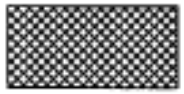
Material Definitions

Double surface dressing

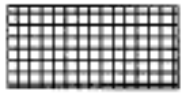
Flexible bituminous surface

Bituminous surface
(Usually a wearing course, WC, and a basecourse, BC)

Bituminous roadbase, RB



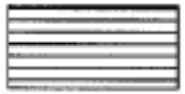
Granular roadbase, GB1 - GB3



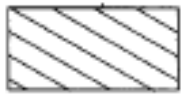
Granular sub-base, GS

Granular capping layer or selected subgrade fill, GC

Cement or lime-stabilised roadbase 1, CB1

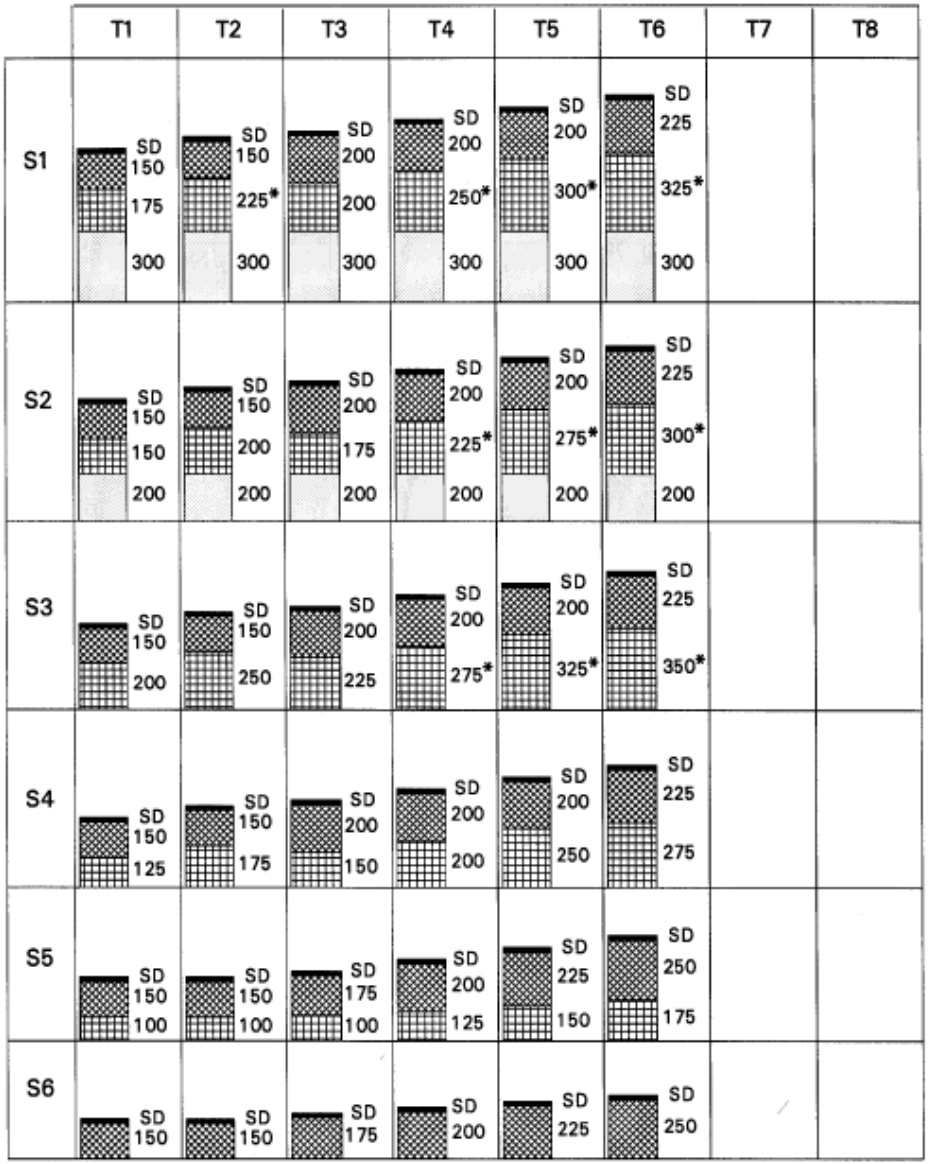


Cement or lime-stabilised roadbase 2, CB2



Cement or lime-stabilised sub-base, CS

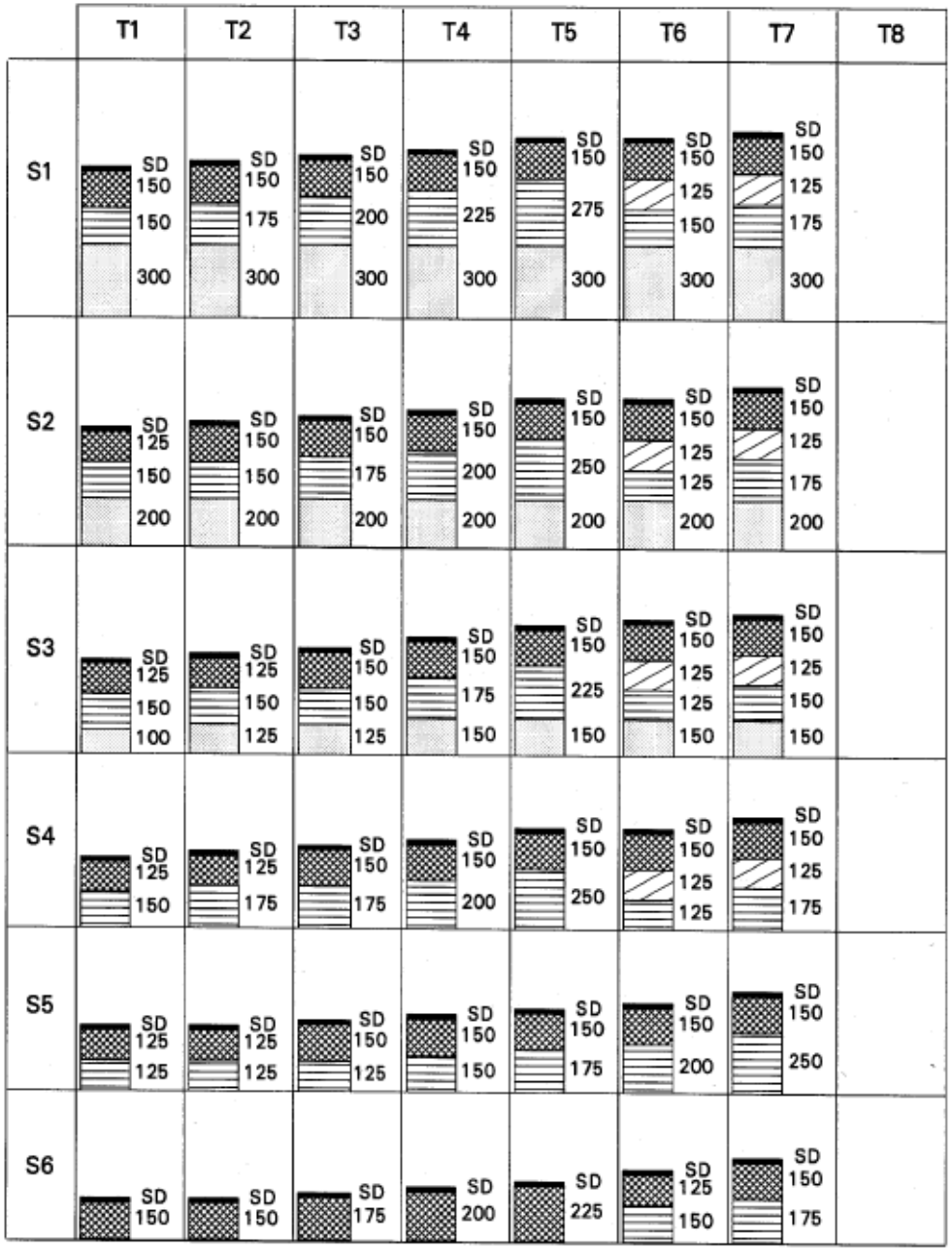
CHART 1 GRANULAR ROADBASE / SURFACE DRESSING



Note: 1 * Up to 100mm of sub-base may be substituted with selected fill provided the sub-base is not reduced to less than the roadbase thickness or 200mm whichever is the greater. The substitution ratio of sub-base to selected fill is 25mm : 32mm.

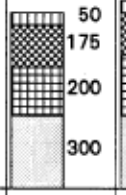
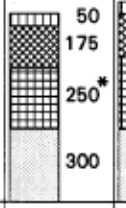
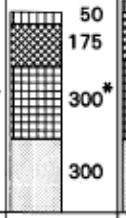
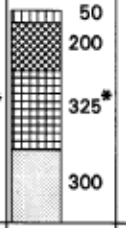
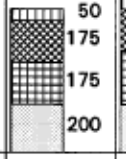
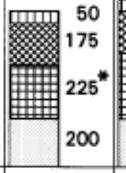
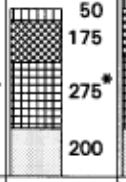
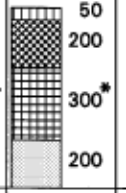
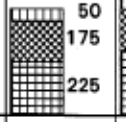
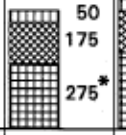
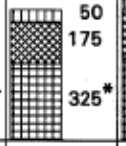
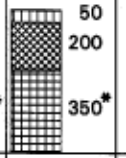
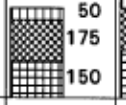
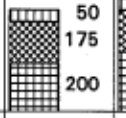
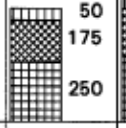
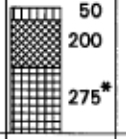
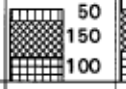
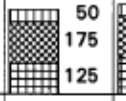
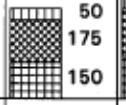
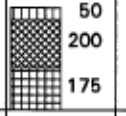
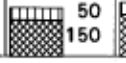
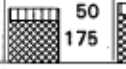
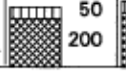
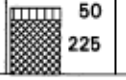
2 A cement or lime-stabilised sub-base may also be used.

CHART 2 COMPOSITE ROAD BASE (UNBOUND & CEMENTED) / SURFACE DRESSING



Note: Sub-base to fill substitution not permitted.

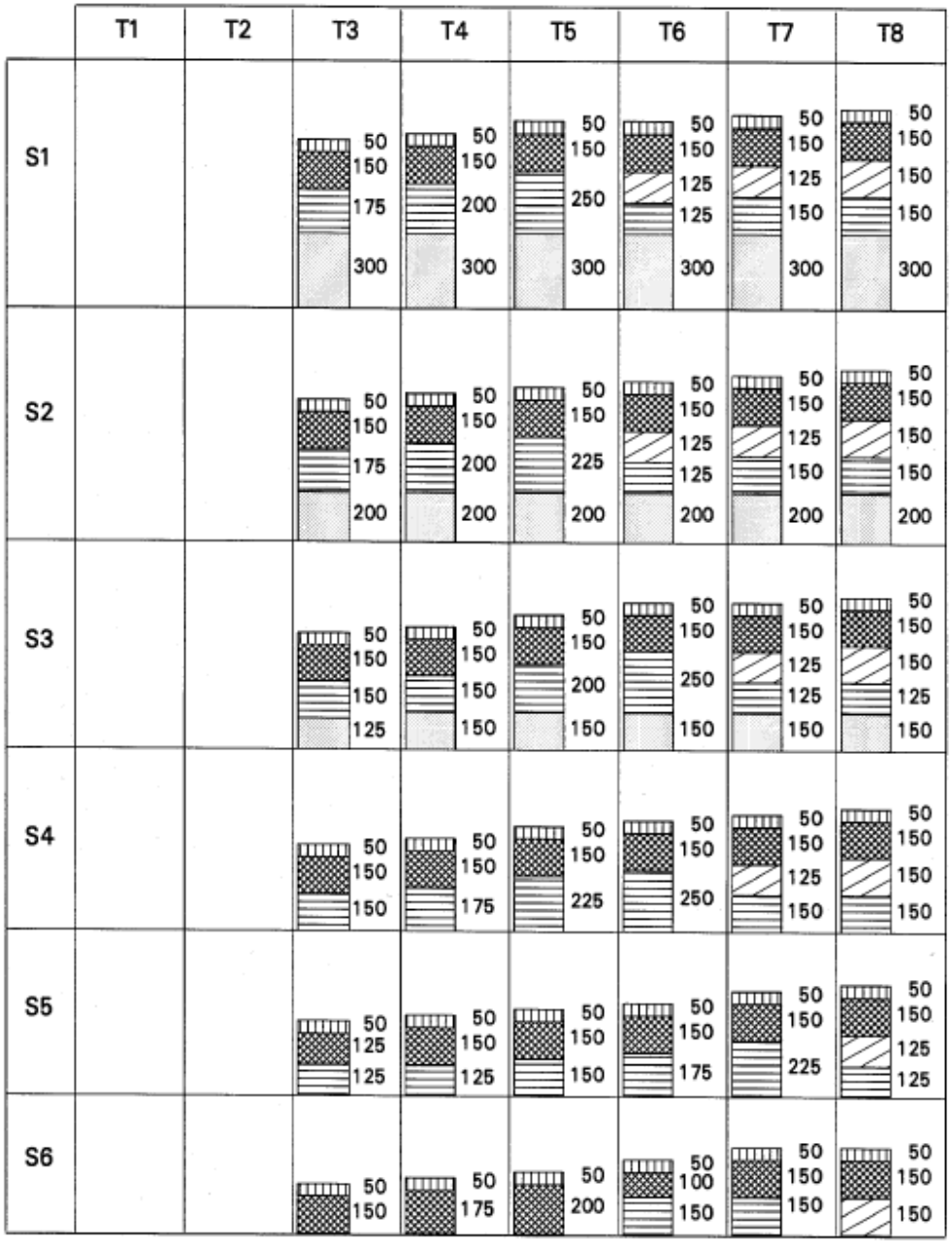
CHART 3 GRANULAR ROADBASE / SEMI-STRUCTURAL SURFACE

	T1	T2	T3	T4	T5	T6	T7	T8
S1								
S2								
S3								
S4								
S5								
S6								

Note: 1 * Up to 100mm of sub-base may be substituted with selected fill provided the sub-base is not reduced to less than the roadbase thickness or 200mm whichever is the greater. The substitution ratio of sub-base to selected fill is 25mm : 32mm.

2 A cement or lime-stabilised sub-base may also be used.

CHART 4 COMPOSITE ROADBASE / SEMI - STRUCTURAL SURFACE



Note: Sub-base to fill substitution not permitted.

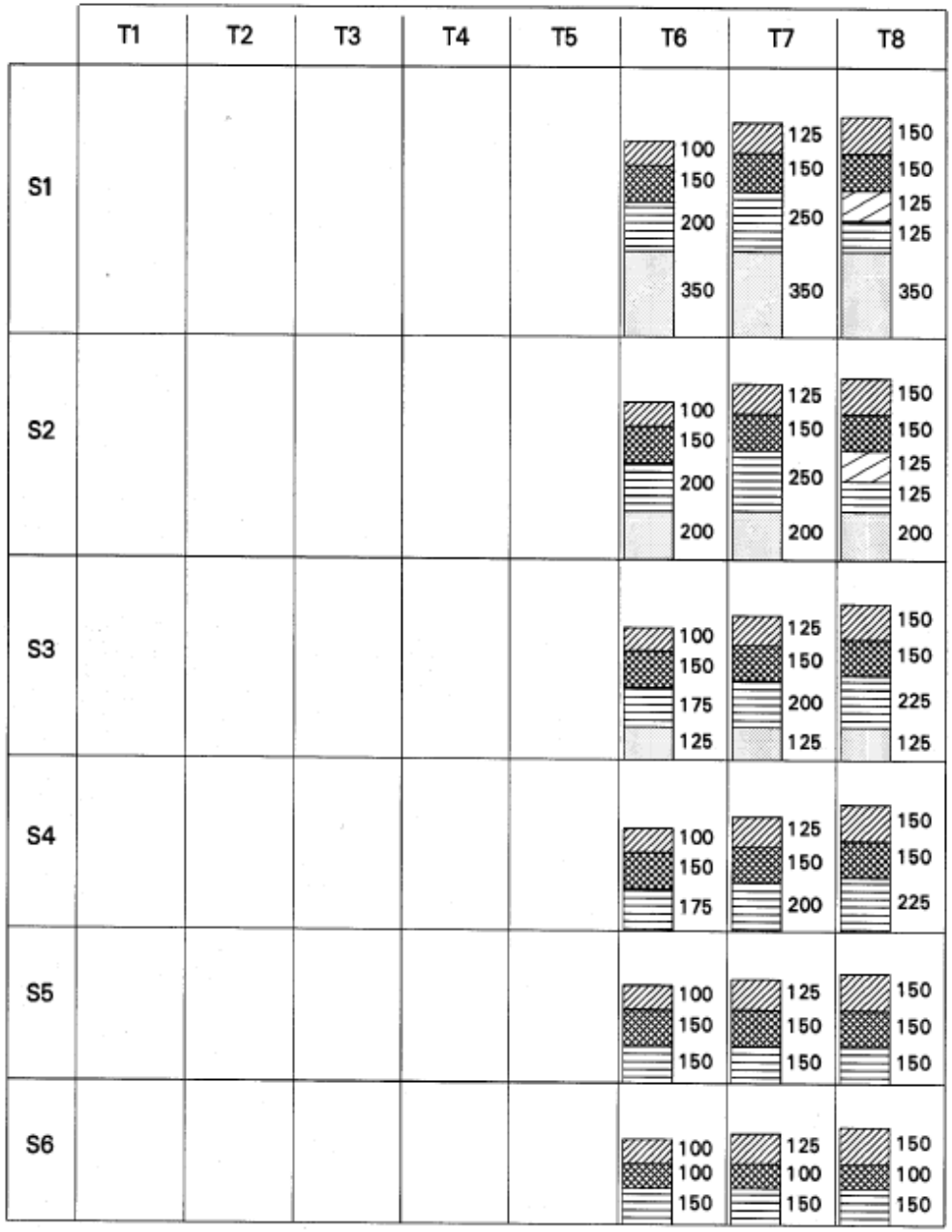
CHART 5 GRANULAR ROADBASE / STRUCTURAL SURFACE

	T1	T2	T3	T4	T5	T6	T7	T8
S1						100 200 225 * 350	125 225 225 350	150 250 250 350
S2						100 200 225 * 200	125 225 225 200	150 250 250 200
S3						100 200 250	125 225 250	150 250 275
S4						100 200 175	125 225 175	150 250 175
S5						100 200 100	125 225 100	150 250 100
S6						100 200	125 225	150 250

Note: 1 * Up to 100mm of sub-base may be substituted with selected fill provided the sub-base is not reduced to less than the roadbase thickness or 200mm whichever is the greater. The substitution ratio of sub-base to selected fill is 25mm : 32mm.

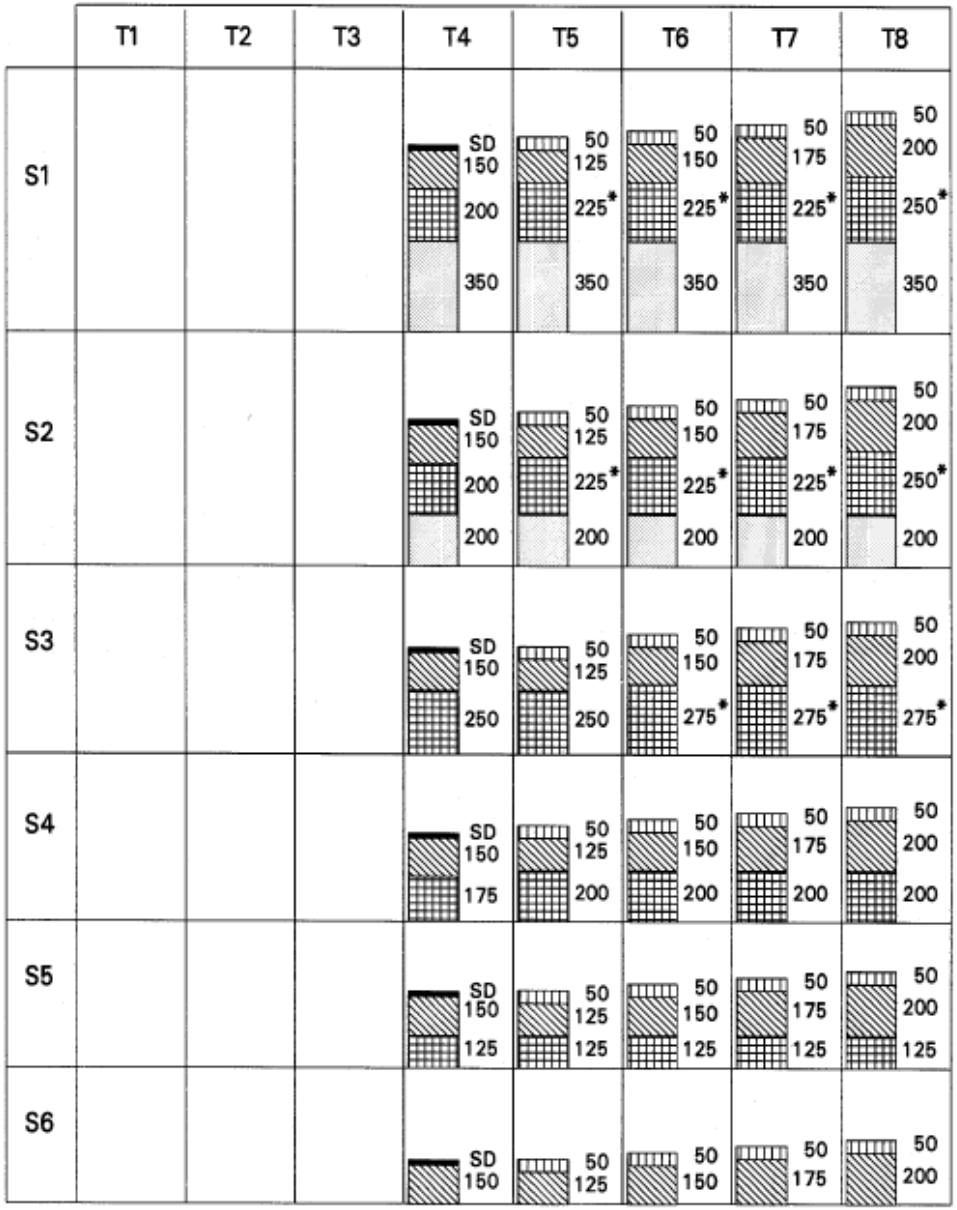
2 A cement or lime-stabilised sub-base may also be used.

CHART 6 COMPOSITE ROADBASE / STRUCTURAL SURFACE



Note: Sub-base to fill substitution not permitted.

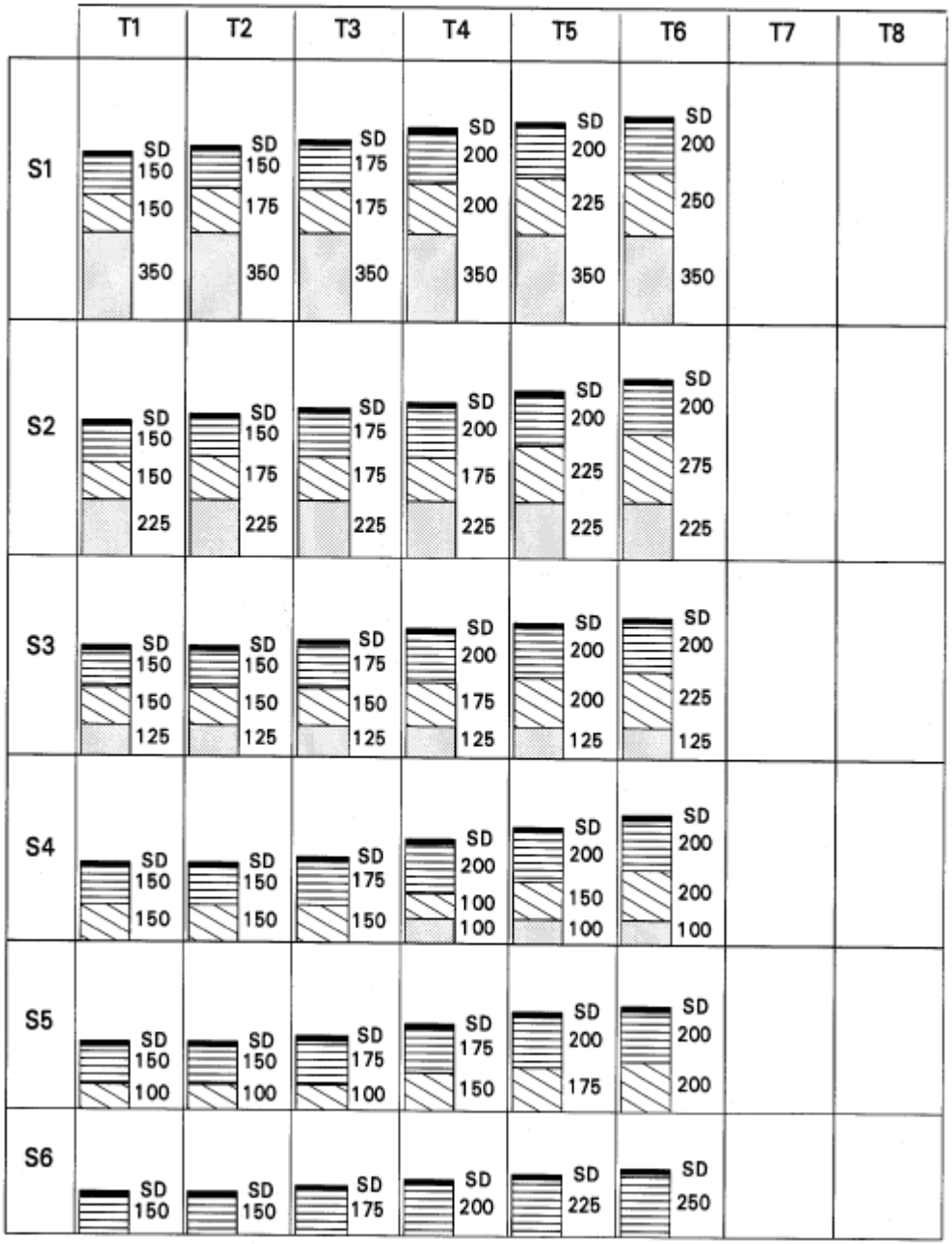
CHART 7 BITUMINOUS ROADBASE / SEMI-STRUCTURAL SURFACE



Note: 1 * Up to 100mm of sub-base may be substituted with selected fill provided the sub-base is not reduced to less than the roadbase thickness or 200mm whichever is the greater. The substitution ratio of sub-base to selected fill is 25mm : 32mm.

2 A cement or lime-stabilised sub-base may also be used but see Section 7.7.2.

CHART 8 CEMENTED ROADBASE /' SURFACE DRESSING



Note: A granular sub-base may also be used.