HIGHWAYS DEPARTMENT

GUIDANCE NOTES
ON
NOISE REDUCING ROAD SURFACING

Research & Development Division

RD/GN/011B
July 2001

HIGHWAYS DEPARTMENT

GUIDANCE NOTE

Noise Reducing Road Surfacing

(supersedes Publication No. RD/GN/011/A titled "Noise Reducing Highway Surfacing" issued in December 1994)

Research & Development Division
Highways Department
Publication No. RD/GN/011/B

Date: July 2001

Noise Reducing Road Surfacing

1. Introduction

1.1 The purpose of this guidance note is to provide technical guidelines for the application of noise reducing road surfacing material for different types of road. Such application is usually identified in the environmental impact assessment process as the noise mitigation measures of reducing the traffic noise induced by the interaction between road surface and vehicle tyres.

1.2 Application of noise reducing road surfacing is just one form of noise mitigation measures. In particular for porous friction course, because of its relatively short service life, high recurrent consequence and environmental nuisance arising from more frequent maintenance requirement, its application on low speed roads should be considered with full justification and reasons for it is the most appropriate form of noise mitigation measure.

2. Background

2.1 The Environmental Impact Assessment (EIA) process becomes a statutory requirement since the implementation of EIA Ordinance in April 1998. Under the EIA process, the noise impact will be assessed at the outset of planning of road projects as traffic noise is a continual problem in Hong Kong.

2.2 To avoid reducing the development capacity of potential sites, Government guidelines stipulate that direct mitigation measures, in particular those that can reduce noise at source, should be considered. Application of noise reducing road surfacing is considered one of the measures for noise mitigation.

3. Noise generated from Traffic

3.1 Noise from road traffic has become, over the last few years, a very contentious environmental issue. Reducing traffic noise is a subject of understanding the tyre/road/vehicle/noise generation mechanisms and is of an inter-disciplinary nature. The quality of the road surface, tyre design, vehicle system and speeds all have an effect on traffic noise.

3.2 Where traffic speeds are lower than 50 km/h, traffic noise is mainly attributable to engine, transmission and exhaust noise, especially from lorries. Where speeds are higher, the major component of traffic noise comes from the tyre/road interaction. This noise comes from, amongst other things, vibration of the tyre wall, compression of air within the contact area of the tyre, and the snapping out of the tread blocks as they leave the road surface.

3.3 The road surface texture plays a significant role in generating noise. A rougher surface increases the contact patch, which exacerbates tyre/road noise as the noise is relative to the length of the escape path for the trapped air. At high speed the compression and release of air trapped under the tyre is a significant component of tyre noise. Road surfaces with negative macrotextures (the depth of texture below the road surface), provided there is sufficient interconnection between the voids below the running surface, allow air trapped beneath the tyre to escape and hence reduce the amount of noise generated by reducing the air pressures within the contact area.

3.4 During wet weather, noise can be generated by traffic as a result of spray generated by moving vehicles. Provision of an effective path for rapid draining water from the road surface is important in reducing the incidence of noise caused by the generation of spray.

4. Noise Reducing Road Surfacing Materials

4.1 Friction Course (with polymer modified binder to improve durability)

4.1.1 Friction course, a porous type of bituminous surfacing, was originally designed to improve skid resistance by virtue of its open texture. Because of the acoustic absorption and rapid drainage properties of the material, it has been revealed by overseas research that porous friction course can also reduce traffic noise induced by the interaction between road surfaces and vehicles tyres of high speed traffic. Porous friction course, when newly laid, is currently the quietest material with a reduction in noise (compared to newly laid traditional bituminous surfacing) of about 4 to 5dB(A). Unfortunately, the interconnected voids allow excellent access to air, so ageing and embrittlement is potentially exacerbated. To improve its durability, polymer modified binder is normally applied in the friction course mixtures to modify the properties of bitumen so as to increase binder film thickness.

4.1.2 For predicting noise from road schemes in accordance with the "Calculation of Road Traffic Noise" published by the UK Department of Transport, which has been adopted in the Technical Memorandum issued under the EIA Ordinance, a noise level of 3.5dB(A) should be subtracted from the basic noise level for all traffic speeds for roads surfaced with porous friction course material. For low speed roads, use of porous friction course material will have a noise reduction value of 2.5dB(A) more than that for traditional impervious bituminous and concrete surfacings, since 1dB(A) is allowed to be subtracted from the basic noise level for impervious bituminous and concrete road surfaces.

4.1.3 The polymers that have been used locally are Asphapol 2000, Polybilt 503, Butonal LS 131 and RLA 2097/1. RLA 2097/1 is currently used in the approved mixes produced by all four bituminous suppliers. Subject to trials of the material to the satisfaction of the Research and Development Division, other alternative polymers or additives proposed by the contractor/supplier may be included in the above list.

4.1.4 Trial on High Speed Road

A trial overlay of polymer modified friction course on a section of Island Eastern Corridor was conducted in 1987 to study its traffic noise reduction performance. A noise reduction of about 5dB(A) was measured immediately after completion of the overlay. However, the noise reduction effect was decreased gradually to 2dB(A) towards the end of life cycle of the friction course, probably due to gradual reduction in porosity by virtue of secondary compression and clogging up of the pores with detritus.

4.1.5 Trial on Low Speed Road

A trial study was commenced in 1995 to look into the practical problems and cost-effectiveness on the use of porous friction course as noise mitigation

measures on low speed roads with speed limit of 50 km/h or below. A Steering Group chaired by the Deputy Director of HyD and comprised representatives from Research and Development Division of HyD, PELB, TB, EPD was formed to oversee the trial study. In the study, different mixes of porous friction course materials were overlaid on five road sections of different gradient. The noise level was monitored for a period of two years while durability of the different friction course materials were checked for a period of three years. The trial study results found that a maximum of 4dB(A) reduction, immediately after laying of the friction course, was measured at some road sections. However, the attenuation figure dropped sharply, without any major pavement defects observed, by some 40% and 60% at the 6-month time and 12-month time respectively. Major pavement defects observed about 18 months after laying. The noise reduction further dropped to about 1.5dB(A) at the end of the 24-month period. The significant drop in the noise reduction at the early stage was probably due to clogging up of the voids with dust deposited in the local road area, which reduced the acoustic absorption of the porous material. Deterioration of porous friction course with time caused further closing up of voids and consequent loss of texture and porosity. (For further detailed information, please refer to Technical Report No. RD/TR/022)

4.2 Stone Mastic Asphalt

4.2.1 Stone mastic asphalt (SMA) essentially consists of discrete and almost single sized aggregate particles forming a skeletal structure bonded together by mastic. The mastic consists of a blend of crushed rock, sand, filler (usually ground limestone) and an additive or modifier to prevent binder drainage while the material is hot. Because of its 'negative' texture, noise measurements in other countries have shown that SMA, which provides good skidding resistance at all speeds and facilitates the drainage of surface water, is quieter than traditional bituminous surfacing by about 2 to 3dB(A).

4.2.2 Trial on Low Speed Road

a) A trial on a section of Lung Cheung Road outside Tin Ma Court with a longitudinal gradient and free flow traffic was conducted in 1997. A noise reduction of about 2.7dB(A) was measured immediately after completion of the overlay, which is slightly less than that for the porous friction course material laid within the same section of Lung Cheung Road. However, the attenuation figure decreased to about 1.8dB(A) after 21-month monitoring period. Road surface defects such as potholes were observed about 14 months after laying.

b) A trial on a section of Siu Lek Yuen Road, Sha Tin was conducted in 1997. A noise reduction of about 1.1dB(A) was measured immediately after completion of the overlay, which is however less than the noise reduction value of 1.5dB(A) obtained for the wearing course material laid within the same section of Siu Lek Yuen Road. The attenuation figure dropped to about 0.4dB(A) after 12-month monitoring period. Road surface defects such as flushing were observed about 16 months after laying.

4.2.3 Overseas experience has shown that SMA mixes are vulnerable to small variations in aggregate grading and binder content, which can result in a reduction in surface texture. SMA to the same specification but using aggregate from different sources, laid on a variety of trial sites on roads in the UK, have

produced inconsistent results in terms of the texture retention. In consequence, further trials on different SMA designed mixes have to be carried out before SMA to a generic specification can be developed and used as a noise reducing road surfacing material in Hong Kong

4.3 Exposed Aggregate Concrete Surface

Exposed aggregate concrete surface (EACS), commonly known as 'whisper concrete', can provide a long life road surface with lower traffic noise than conventional bituminous surfaced road and is the quietest concrete surface currently available. It can be used in any location, including low speed and heavily trafficked roads. The coarse aggregate used in the EACS has a specific requirement with the minimum polished stone value, which is however not available in the current local quarries. Trials on its suitability of general use in Hong Kong are therefore unable to be carried out.

4.4 Proprietary Thin Layer Noise Reducing Surfacing

There are a number of proprietary products of thin surfacings developed for both new construction and maintenance. As a result of their flat, machine laid surfaces and uniform negative surface texture, some thin surfacings can be significantly quieter than traditional impervious surfacing. However, at the present stage of their development, they are not as quiet as newly laid porous friction course. Besides, trials have to be conducted to demonstrate their suitability of use in Hong Kong.

5. Noise Reducing Road Surfacing as Standard Road Surfacing Material for High Speed Roads

5.1 Since 1987, a number of suitable high speed road sections with free flow traffic running at 70 km/h or above have been overlaid with polymer modified friction course as a noise mitigation measure under a programme overseen by EPD. The last two sections of existing high speed roads under the programme were completed in 1999. On the other hand, the porous friction course has become the standard surfacing for all new high speed roads in Hong Kong as its use is generally recommended in the Transport Planning & Design Manual for

(i) minimization of road spray from vehicle during wet weather;
(ii) greatly increased texture depth;
(iii) reduction of the potential for vehicles to aquaplane; and
(iv) improved skid resistance at high speeds.

5.2 The noise reducing surfacing on high speed roads should be applied with the following compositions:

- Concrete pavement: 30mm thick 10mm nominal size polymer modified friction course on 20mm thick 3.35mm nominal size polymer modified cushion course.
- Bituminous pavement: 30mm thick 10mm nominal size polymer modified friction course on 25mm thick 10mm nominal size regulating wearing course, or 30mm thick 10mm nominal size polymer modified friction course on 20mm nominal size wearing course of newly constructed pavement.

6. Noise Reducing Road Surfacing as Noise Mitigation Measures on Low Speed Roads

Under existing policy for new local roads, low noise surfacing materials should be used under exceptional circumstances where noise reduction is an absolute necessity but cannot be achieved by any other means. For existing local roads, 72 road sections have been identified for resurfacing with low noise materials subject to detailed feasibility study to be carried out by HyD in consultation with EPD.

In accordance with the trial study mentioned in paragraph 4.1.5, the following noise reducing road surface

- Bituminous pavement: 30mm thick 10mm nominal size polymer modified friction course on 45mm thick wearing course

(Concrete pavement: not applied as further study and trials have yet to be carried out.)

may be applied for low speed roads subject to conditions as listed below:

i. Not on inclined roads;
ii. No sharp bend in road geometry;
iii. Average annual daily traffic not exceeding 18,500 in traffic volume and percentage of commercial vehicles not exceeding 35%; and
iv. Not on roads where a minimum crossfall of 2.5% cannot be practically achieved to drain water to the roadside gullies effectively. (for minimizing occurrence of flooding in the porous friction course material)

7. Application

7.1 Checking of Structure Loading

Any overlay will increase the superimposed dead load of an existing structure. Confirmation must be obtained from CHE/Str. that the structure (e.g. flyover, road bridge) can withstand the additional loading.

7.2 Material Specifications

3.35mm nominal size polymer modified cushion course material shall meet the requirements of Table 1. 10mm nominal size polymer modified friction course material shall meet the requirements of Table 2.

7.3 Flyover with Concrete Surfacing (for high speed roads only)

The depth of overlay should be minimised as it reduces the upstand of barriers and kerbs. A 50mm overlay of polymer modified asphalt comprising 20mm thick 3.35mm nominal size polymer modified cushion course material and 30mm thick 10mm nominal size polymer modified friction course material should be adopted as the standard for this type of operation. The height of vehicular bridge parapet wall shall not be less than 1m in accordance with the Structures Design Manual. This minimum parapet height must still be maintained after overlaying on the adjacent road surface. Prior to overlaying, the concrete surface should be cleaned to ensure good bonding with the overlay materials.

7.3.1 Bridge Joints

For raising existing expansion joints, CHE/Str. should be consulted with the proposed works.

In case any joint raising work is anticipated, the reference level for the overlay surface should make reference to the future joint level in order to maintain a smooth riding road surface. However, the raised bridge joint may obstruct surface water draining through the porous friction course. Provision of gullies should be considered as ponding may occur at the bridge joint if there is no gully to collect the rainwater draining along the joint. The design of such drainage system should be carried out by relevant Regional Offices or Project Offices.

For fixed joints, overlay details shown in drawing GN/011/01A shall be used. These details may be changed from time to time as further experience is obtained.

7.3.2 Gully Grating and Rodding Eye Covers

Gully grating wholly or partly inside the carriageway shall be raised to match with the overlay material. The raising of gully gratings will not be required if they are outside the carriageway.

Raising of gully gratings and rodding eye covers by 50mm usually have negligible effect on a structure. Typical details are shown in drawings GN/011/02B-04B. However, CHE/Str. can be consulted if it is considered to be relevant.

7.4 Flyover and At-grade Carriageway with Bituminous Surfacing

7.4.1 Surfacing without Friction Course Material

For at-grade carriageway and flyover with buried joints, the top 25mm of the existing bituminous surfacing layer or the whole thickness of the existing surfacing if its nominal thickness is less than 50mm, shall be milled off and regulated with 10mm nominal size wearing course material specified in Section 9 of General Specification for Civil Engineering Works 1992 Edition. A 30mm thick polymer modified friction course shall be added as the uppermost pavement layer. Gully gratings wholly or partly inside the carriageway shall be raised to match with the overlay material using details shown in drawings GN/011/02B & 03B. If the gratings are outside the carriageway, raising of the gratings will not be required. Rodding eye covers shall be raised using details shown in drawings GN/011/04B. For at-grade carriageway, raising of kerbs, footways and central dividers due to the application of the overlay will not normally be required.

For flyovers with exposed joints, inlay of bituminous surfacing material shall be adopted. If the nominal thickness of the existing bituminous surfacing material is not less than 100mm, the top 55mm material shall be milled off, regulated with 25mm thick 10mm nominal size wearing course and 30mm polymer modified friction course. Otherwise, the top 50mm material shall be milled off and laid with 20mm thick 3.35mm nominal size polymer modified cushion course and 30mm thick 20mm nominal size polymer modified friction course. Gully gratings shall be modified in accordance with HyD Standard Drawing H3106A. However, the existing bridge joint may obstruct surface water draining through the porous friction course. Provision of gullies should be considered as ponding may occur at the bridge joint if there is no gully to collect the rainwater draining along the joint. The design of such drainage system should be carried out by relevant Regional Offices or Project Offices.

7.4.2 Surfacing with Friction Course Material

If the life of porous friction course material has expired due to oxidation or other premature failures, it should be milled off and re-laid with polymer modified friction course material if its application is required for noise reducing purpose. Should the existing underlying surfacing be damaged during the milling operation, re-surfacing the underlying layer shall be in accordance with paragraph 7.4.1 to ensure a smooth running surface for effective drainage prior to laying of polymer modified friction course. Gully gratings shall be modified in accordance with HyD Standard Drawing H3106A.

7.5 At-grade Carriageway with Concrete Surfacing (for high speed roads only)

An overlay material comprising 20mm thick 3.35mm nominal size polymer modified cushion course and 30mm thick 10mm nominal size polymer modified friction course should be used. Prior to overlaying, all road defects such as spalling, unsupported slab and areas of settlement should be rectified. At road slab joint, details shown in drawing GN/011/06B should be adopted to minimize the potential for future development of reflective cracking. Treatment for gully gratings shall be in accordance with paragraph 7.3.2. As the overlay thickness is not greater than 50 mm, raising of the kerbs, footways and central dividers would not normally be required.

7.6 End Details

At ends of overlay, detail shown in drawing GN/011/07B should be adopted for flyover and at grade carriageway with concrete surfacing. For carriageway with flexible surfacing, the end ramps should be formed by SMA material. It is necessary to mill off the existing surfacing at the ramps to accommodate the minimum thickness of the new SMA layer that is to form the ramp.

It should be noted that surface water drains through friction course and flows along the surface of the underlying layer according to the road gradient. The ramp at the end of the overlay will stop the flow at the underlying layer. It is therefore important to stop the downstream end of the overlay at the location of a gully and/or install sufficient gullies at the downstream end of the overlay to avoid the accumulation of surface water which may in turn cause pre-mature deterioration of the friction course material.

TABLE 1

3.35 MM NOMINAL SIZE POLYMER MODIFIED CUSHION COURSE: - AGGREGATE GRADING, BITUMEN CONTENT, POLYMER DOSAGE & DESIGN TEST PROPERTIES

Properties		Cushion course
Nominal maximum aggregate size (mm)		3.35
	BS test sieve	Percentage by mass passing
Particle size distribution	6.3 mm	100
	3.35 mm	95 - 100
	1.18 mm	55 - 75
	300 μm	25 - 35
	75 μm	10 - 20
Bitumen content as % of total mass including binder, but excluding polymer	min	9.5
	max	10.5
Dosage of polymer, % of solid content by weight of binder content (see Note 1)		min 5
Marshall Quotient (kN/mm) = Marshall Stability / Flow		0.7 - 1.2

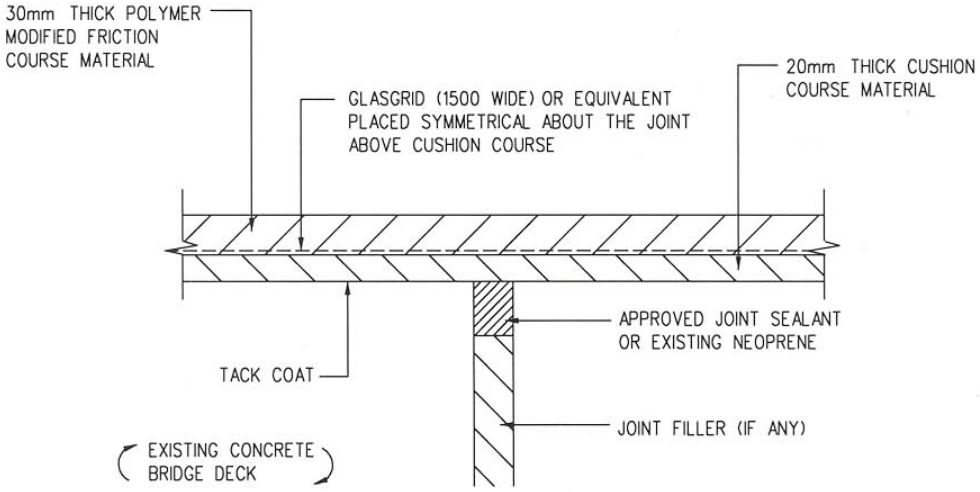
Note 1 : The above mix design requirements are for reference only and are subject to change. Engineers may wish to consult the Research and Development Division for obtaining the latest mix design requirements.

TABLE 2

10 MM NOMINAL SIZE POLYMER MODIFIED BITUMINOUS FRICTION COURSE: - AGGREGATE GRADING, BITUMEN CONTENT, POLYMER DOSAGE & DESIGN TEST PROPERTIES

Properties		Friction course
Nominal maximum aggregate size (mm)		10
	BS test sieve	Percentage by mass passing
Particle size distribution	14 mm	100
	10 mm	85 - 100
	5 mm	20 - 40
	2.36 mm	5 - 15
	75 μm	2 - 6
Bitumen content as % of total mass including binder, but excluding polymer	min	5.5
	max	7.0
Dosage of polymer, % of solid content by weight of binder content (see Note 1)		min 3
Air voids in mix as a percentage of total bulk volume		min 17

Note 1 : The above mix design requirements are for reference only and are subject to change. Engineers may wish to consult the Research and Development Division for obtaining the latest mix design requirements.



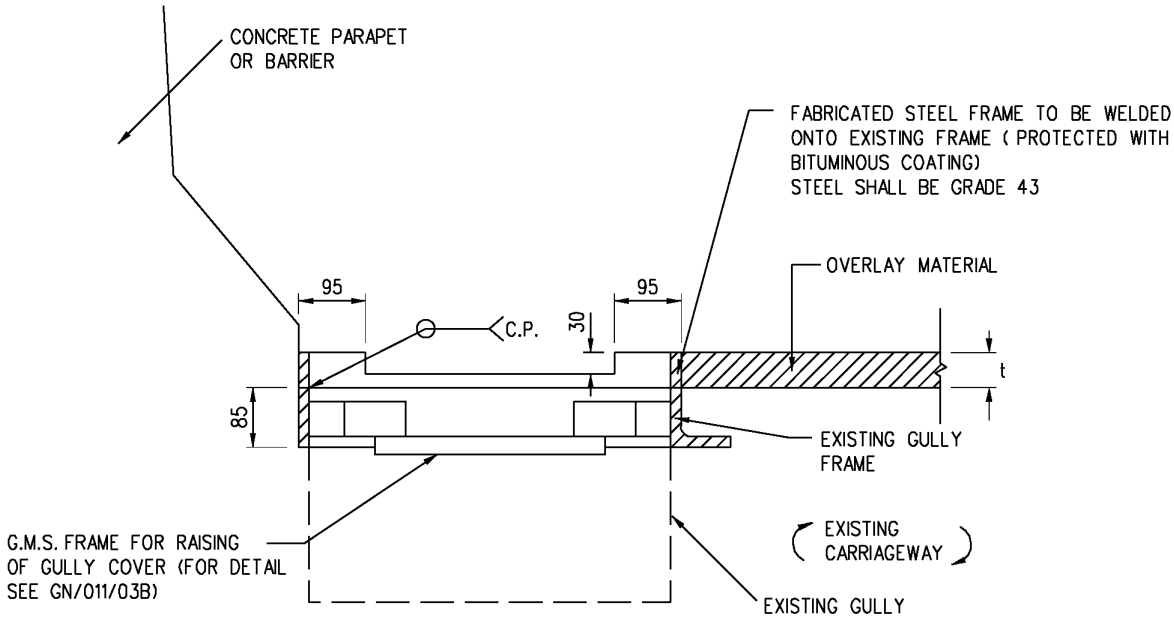
DETAIL OF OVERLAY AT BRIDGE FIXED JOINT

OVERLAY DETAIL AT BRIDGE FIXED JOINT

REF.	REVISION	SIGNATURE	DATE

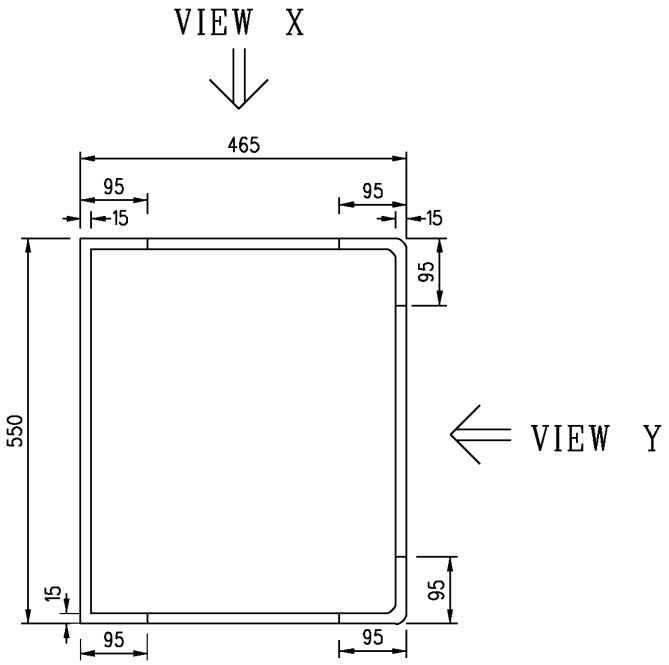
HIGHWAYS DEPARTMENT

REFERENCE	DRAWING No.	CAD
SCALE 1:5	GN/011/01A	

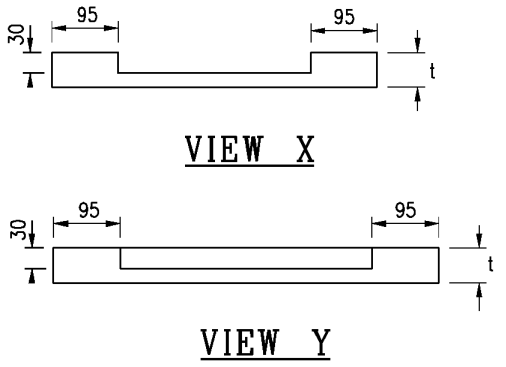


DETAILED SECTION OF RAISED GULLY FRAME

(GULLY GRATING TYPE GA1 - 450 SHOWN)



PLAN OF FABRICATED STEEL FRAME



t = THICKNESS OF OVERLAY MATERIAL

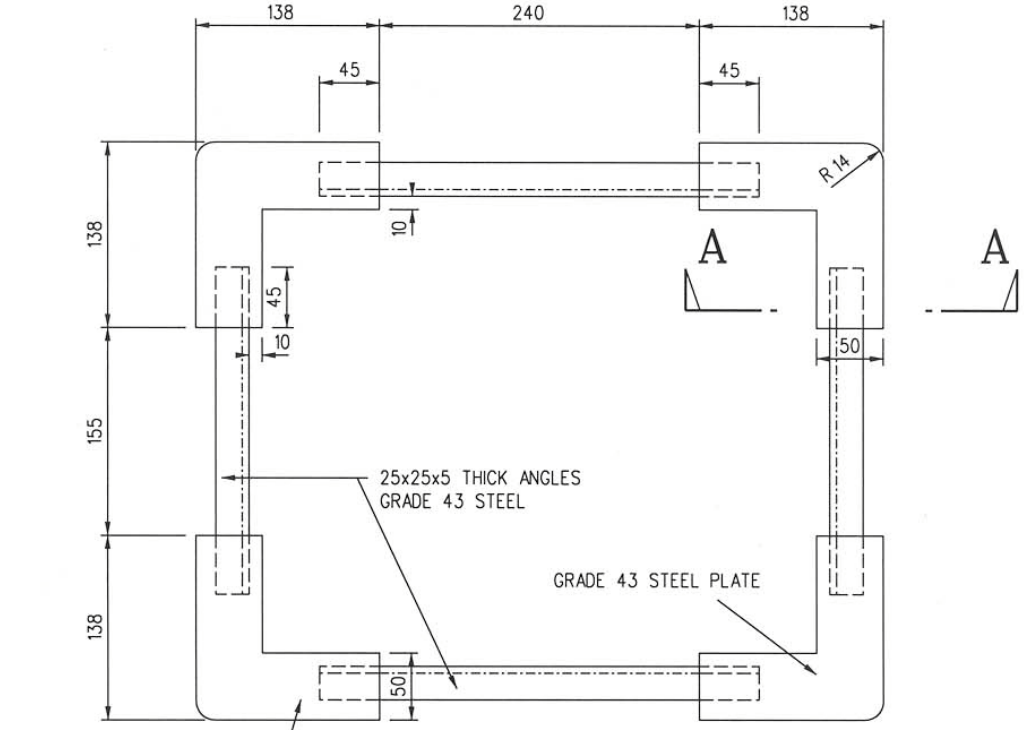
NOTES: DIMENSIONS ARE IN MM

REF.	REVISION	SIGNATURE	DATE
B	Raised gully frame revised		Mar 00

HIGHWAYS DEPARTMENT

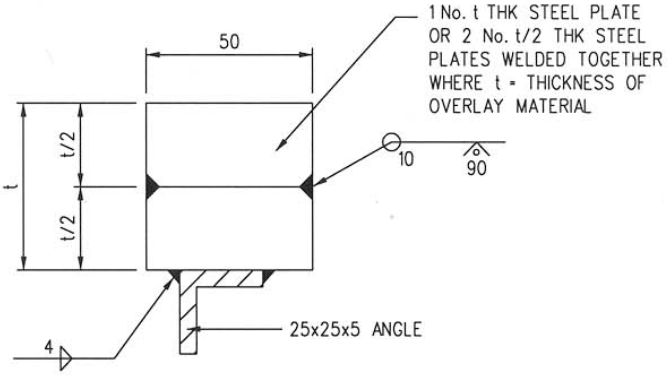
RAISED GULLY FRAME

REFERENCE	DRAWING No.	CAD
SCALE 1 : 10	GN/011/02B	



PLAN

SCALE 1 : 5



SECTION A - A

SCALE 1 : 2

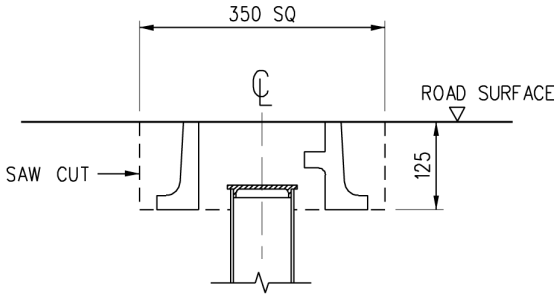
NOTES: DIMENSIONS ARE IN MM

G.M.S. FRAME FOR RAISING OF GULLY GRATING (TYPE GA1 - 450 SHOWN)

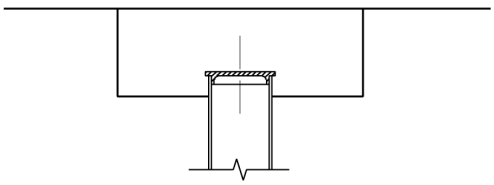
REF.	REVISION	SIGNATURE	DATE
B	General revision		Mar 00

HIGHWAYS DEPARTMENT

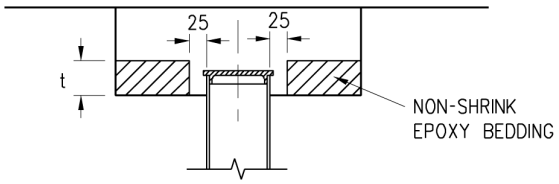
REFERENCE	DRAWING No.	CAD
SCALE: AS SHWON	GN/011/03B	



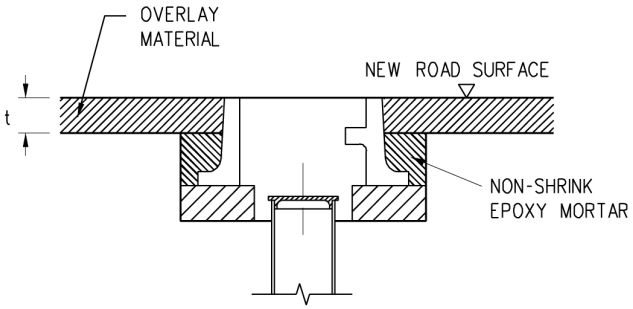
1. SAW CUT TO THE BOTTOM OF THE RODDING EYE COVER (APPROX. 125mm) CARE MUST BE EXERCISED IN SAW CUTTING AND BREAKING UP CONCRETE TO AVOID DAMAGE TO THE REINFORCEMENT AND DOWN PIPE AND TO ENSURE NO MATERIAL FALLS INTO THE RODDING EYE.



2. TAKE OFF THE RODDING EYE COVER BY HAND TRIMMING



3. ADJUST THE LEVEL OF THE COVER WITH NON-SHRINK EPOXY BEDDING



4. INSTALL NEW RODDING EYE COVER TO H3114A & H3115A

t = THICKNESS OF OVERLAY MATERIAL

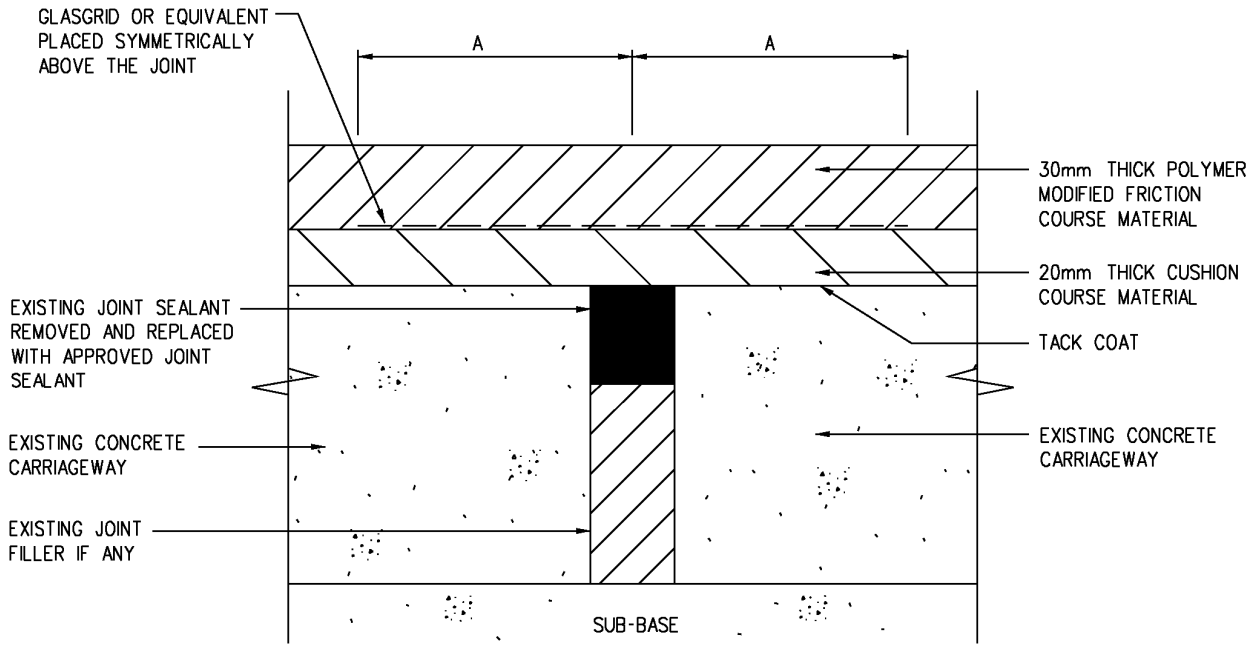
NOTES: DIMENSION ARE IN MM

B	GENERAL REVISION		MAR 00
REF.	REVISION	SIGNATURE	DATE

HIGHWAYS DEPARTMENT

DETAILS OF RAISING RODDING EYE COVER

REFERENCE	DRAWING No. CAD
SCALE 1 : 10	GN/011/04B



OVERLAY WITH 50mm BITUMINOUS MATERIAL

A- 750mm AT LONGITUDINAL, TRANSVERSE EXPANSION & CONTRACTION JOINTS

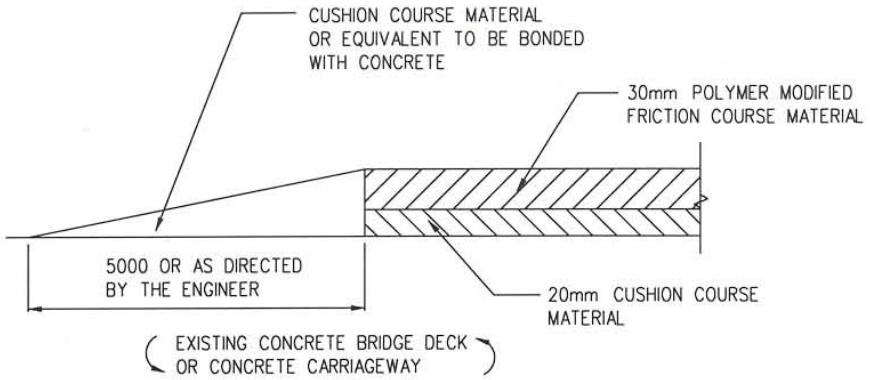
A- 350mm AT BOXOUT JOINT

DETAILS OF OVERLAY AT CONCRETE CARRIAGEWAY LONGITUDINAL, EXPANSION, CONTRACTION AND BOXOUT JOINTS

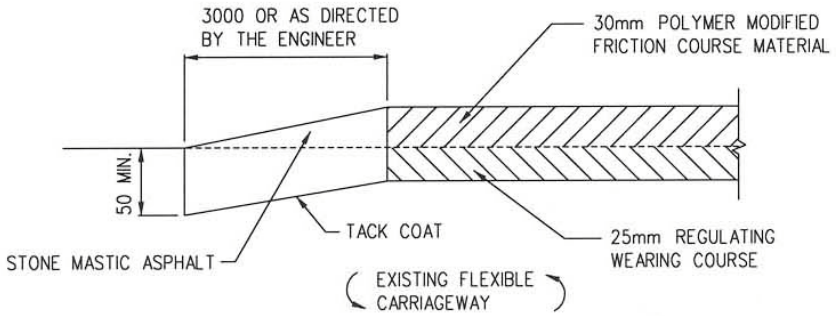
REF.	REVISION	SIGNATURE	DATE
B	GENERAL REVISION		MAR 00

HIGHWAYS DEPARTMENT

REFERENCE	DRAWING No.	CAD
SCALE Schematic	GN/011/06B	



FOR CONCRETE BRIDGE DECK OR AT GRADE CONCRETE CARRIAGEWAY



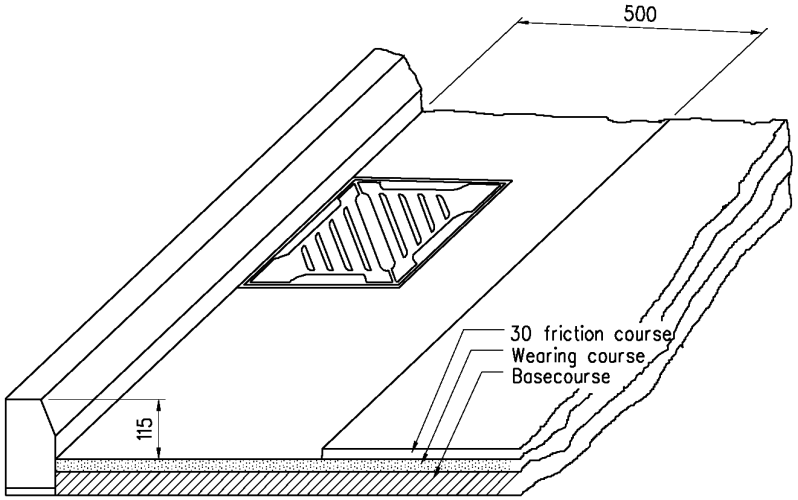
FOR FLEXIBLE CARRIAGEWAY

DETAILED SECTION OF STOP ENDS

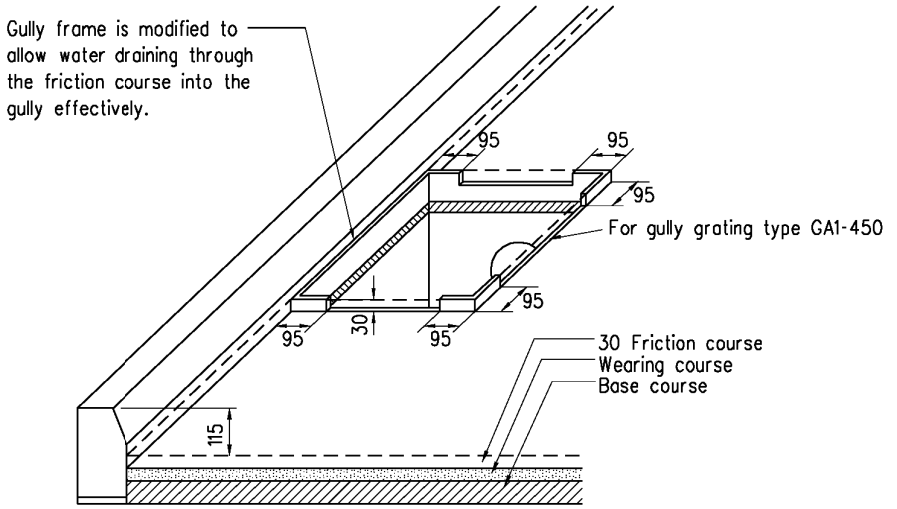
REF.	REVISION	SIGNATURE	DATE
B	END DETAILS FOR FLEXIBLE CARRIAGEWAY ADDED		MAR 00

HIGHWAYS DEPARTMENT

REFERENCE	DRAWING No.	CAD
SCALE HOR. 1:100 VERT. 1:5	GN/011/07B	



CARRIAGEWAY WITH HARD SHOULDER
EQUAL TO OR WIDER THAN 2500MM



CARRIAGEWAY WITHOUT HARD SHOULDER
OR WIDTH OF HARD SHOULDER IS LESS THAN 2500MM

Notes :

1. Dimensions are in millimetres.
2. Kerb overflow weir may be required but is not shown for clarity.

REF.	REVISION	SIGNATURE	DATE
A	Gully frame revised		Mar 00
	Former drg. no. H3003/2 with general revision		June 94

INSTALLATION OF GULLY GRATINGS IN FLEXIBLE PAVEMENTS WITH FRICTION COURSE

HIGHWAYS DEPARTMENT

REFERENCE	DRAWING No.	CAD
SCALE Diagrammatic	H 3106A	