HIGHWAYS DEPARTMENT

GUIDANCE NOTES

ON

ROAD MARKINGS

Research & Development Division

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Contents

Guidance Notes on Road Markings

1. INTRODUCTION

This set of Guidance Notes updates HyD Guidance Notes No. RD/GN/036 (which is hereby superseded) to incorporate the latest research findings. In particular, details on common factors that will affect the in-service performance of thermoplastic road markings and removal of existing road markings are further elaborated in this Guidance Note.

2. BACKGROUND

2.1 Road Note No. 7 was published in 1984 to promulgate the use of thermoplastic road marking materials to replace road marking paint. The major advantages of hot applied thermoplastic road marking are its improvement of reflectorisation at night with the addition of glass beads and that it is more durable than road marking paints. These advantages outweigh the higher initial cost of using thermoplastic materials.

2.2 Since the publication of Road Note No.7, more local experiences, worldwide developments and research findings have been gained. Guidance Notes on Application of Thermoplastic Materials for Road Markings (RD/GN/036) was published in 2010 based on the outcome of the collaboration study among the Research and Development (R&D) Division of the Highways Department and the Hong Kong Polytechnic University on road marking technology.

2.3 In recent years, further study was carried in collaboration with Chu Hai College of Higher Education to identify measures for ensuring the in-service performance of road markings. Common factors that will affect the in-service performance of thermoplastic road markings and control measures were identified in the study. The findings of successful trial and application of new techniques for removing and masking existing road markings are also incorporated in this updated Guidance Notes.

3. THERMOPLASTIC ROAD MARKING MATERIALS

3.1 General

In Hong Kong, alkyl type thermoplastic material becomes more popular in recent years over hydrocarbon type material mainly due to their better resistance to petroleum products like engine oil. The alkyl type thermoplastic is less oil-soluble than the hydrocarbon type thermoplastic. Hardened alkyl thermoplastic also has stronger internal bonding than hydrocarbon thermoplastic. This reduces the chance on formation of a sticky surface that may easily attract dirt from the surrounding. Therefore, alkyl type thermoplastic is preferred to be used under dusty environment in urban area.

By considering the different merits and drawbacks of the alkyl and hydrocarbon type thermoplastics, the recommendations on their usage are laid down in Table 1.

Table 1: Recommendation on the Usage of Alkyl and Hydrocarbon Thermoplastic Materials

Type of Thermoplastic Materials	Merits	Drawbacks	Recommended Usage
Alkyl	More resistance to petroleum products and less prone to blackening.	Cost is slightly higher than hydrocarbon type thermoplastic. Material may be more easily discoloured due to overheating.	Must be used on roads which are not high speed roads.
Hydrocarbon	Cost is generally lower than alkyl type thermoplastic. Its finished colour is sharper when compared with that of alkyl type thermoplastic, overheating has less effect on the colour of the material.	Material can be softened by petroleum products and attracts dirt more easily.	More appropriate for use on high speed roads.

3.2 Requirements of Materials

The performance of the road markings depends greatly on the physical properties of their constituents. Critical constituents are thermoplastic binder, titanium dioxide, colour pigment, glass beads and anti-skid aggregates. They should meet the requirements stipulated in the relevant standards summarised in Table 2 below:

Table 2: Relevant standards for the requirements of materials

Materials	Standard No.	Title
Thermoplastic binder	BS EN 1871	Road marking materials - Physical properties
Premix glass beads	BS EN 1424	Road marking materials - Pre-mix glass beads
Drop on glass beads and anti-skid aggregates	BS EN 1423	Road marking materials - Drop on materials – glass beads, anti-skid aggregates and mixture of the two

Based on previous experience, the softening point of the thermoplastic binder, the quality of glass beads and the composition percentage of the thermoplastic material are major factors affecting the performance of the road markings. Table 3 shows the possible impacts against the common defects of the constituents.

Table 3: Common defect of road marking components

Component	Common Defect	Possible End Result
Thermoplastic Materials	Softening point too low	Render softening of the material or loss of glass beads, and Blackening of the material in hot weather.
	Binder content too low	Render early fracturing of the material.
	Insufficient titanium dioxide	Reduce the luminance, retro-reflectivity and resistance to UV light of the road markings.
	Insufficient colour pigment	Impair the colour of the road markings.
Glass Beads	Inadequate roundness or refractive index too low	Greatly reduce the retro-reflectivity of the road markings.

3.3 Guidelines for Construction, Removal, Masking and Repainting

3.3.1 Setting Out

Accurate setting out of the road marking line facilitates easier application and also ensures the smoothness of the lines, particularly for curved lines. For road markings of untypical shapes and forms such as symbols and characters, pattern moulds made of metal, wood or cardboard should be adopted to assure workmanship and efficiency of the site works. Metal mould could be reused for many times but the metal mould can be easily deformed due to temperature variations. The deformation of the metal mould may render poor attachment with the road surface and the liquid form thermoplastic materials may seep underneath the mould during application. Therefore, deformed metal moulds should not be reused. Alternatively, cardboard moulds are lighter and easier to be handled during operation (Refer to Plate no. 1).

3.3.2 Storage of Materials

There are two important aspects for the storage of thermoplastic materials and glass beads.

1. The storage time for the powdered form thermoplastic materials must not exceed the limit as recommended by the manufacturers (a maximum storage period of 6 months is a very common criterion).

2. The powdered form thermoplastic materials and glass beads should be kept in dry places. Excessive absorbance of moisture from air by the thermoplastic powder will render formation of solid lumps and cause difficulty for thorough melting and mixing of the material, even under a sufficiently high application temperature. The wetted glass beads will lead to poor bonding with the thermoplastic binder. Plate no. 2 shows the typical appearance of glass beads which have formed small lumps upon wetting.

3.3.3 Site Preparation

The road surfaces for applying the markings should be clean and dry. Oil and dust must be removed. Application of thermoplastic road markings on

wet (or incompletely cured) or dusty road surfaces may induce early detachment of the material or formation of air bubbles at the surface of the road markings.

On concrete road surfaces, where strong thermal bonding cannot be formed, an approved priming coat shall be utilised prior to the application of thermoplastic materials on the road surface. Similarly, prime coat should be applied to smooth, worn asphaltic road surfaces to achieve adequate adhesion. On new concrete pavements, it is necessary to remove any laitance or curing compounds by wire brushing before the application of primer. Primer is generally applied by pressure sprayer or hand application and it must be allowed to dry before applying the thermoplastic markings. Thermoplastic material flaking off from the pavement surface could occur due to insufficient bonding (Plate no. 3).

3.3.4 Preparation of Materials

Mixing Plant

The mixing plant should be able to provide a minimum rotational speed of 45 revolutions per minute (RPM) to ensure proper mixing. The thermostat system should function properly at all time to avoid overheating of the materials. Displayable temperature gauge should be available for monitoring of the heating temperature (Plate No. 4).

Binder Material

The thermoplastic binder material shall be heated to the designated temperature (i.e. generally < 230^{o}C) for a duration according to the manufacturer's recommendations. Overheating or prolonged heating may cause early discolouration of the material (e.g. yellow to green as shown in Plate no. 5 and white to creamy) and accelerate brittleness of the material during its service life. Insufficient heating may cause problem of incomplete melting of the alkyl resin and poor thermal bonding with the underlying bituminous pavement surface which may lead to early detachment from the road surface (Plate No. 6). For certain types of thermoplastic materials, sufficient flowability can still be resulted under insufficient heating temperature. Flowable thermoplastic material may not be equivalent to

complete melting of the thermoplastic matrix. It is not recommended to simply observe the flowability of the material in determining whether the material is sufficiently heated.

Based on previous experience, substantial blackening was noted in areas in yellow box junctions. It was envisaged that the blackening effect was mainly due to the steering and decelerating action of vehicle tyres at those areas where the loss of rubber fines of vehicle tyres is generally severe. Use of thermoplastic road marking materials with softening point greater than 95^{o}C in those areas could help minimising the blackening effect.

Intermixed Glass Beads

It is important to ensure the presence of intermixed glass beads within the thermoplastic matrix as they contribute significantly on retro-reflectivity during the service life of road markings. The drop on glass beads at the upper portion of the road marking functions properly at the beginning. This upper portion of the marking will gradually be worn away by the running traffic and the intermixed glass beads at lower layer will be exposed to provide adequate long term retro-reflectivity.

The thermoplastic binder material should consist of about 20% by weight of intermixed beads. More than 20% beads mixed in the material can sometimes cause problems of flaking and powdering whilst less than 10% may not provide satisfactory reflective effect at all. If marking material with more than 20% of intermixed beads is proposed, the supervisor must ensure that the product have sufficient and satisfactory track records. The maximum percentage of intermixed beads should not exceed 30% in any case.

Anti-skid Aggregates

The anti-skid aggregates shall be durable (the maximum friability index should not exceed 20%). Its colour should be sufficiently light so that the final retro-reflectivity of the road marking would not be affected. Previous experience shows that the addition of anti-skid aggregates of 10% - 15% (by weight) can provide significant improvement to skid resistance. The completed road markings shall provide skid resistance of at least 45 SRT.

3.3.5 Application of Thermoplastic Materials

Screed Box

Application of thermoplastic materials by screed box is a common practice in Hong Kong and particularly useful for maintenance works and small projects in which the scale of road marking works are relatively small. Since only limited working space is available in most work sites, hand screeding is particularly useful to the applications on box junctions, arrows, letters, characters and the like, where operation of large machineries is relatively inconvenient. Hand screeding requires high skill of the operators. The operators must maintain the speed of the screeding operation as constant as possible in order to achieve even thickness of the marking. The screed box should be pre-heated to the temperature of the melted thermoplastic material to avoid abrupt cooling of the material during application (Plate No. 7). Wear and tear of the screed boxes over time would affect the applied road marking thickness and hence their condition should be checked regularly (Plate no. 8).

It is a good practice to use straight and flexible guiding edges while working on straight and curved markings respectively (Plate nos. 9 and 10). A common mal-practice on site is that the road markings for curved lines are applied in free hand without guiding edge. Plate no. 11 demonstrates the unsatisfactory result of a curved line. Prior placement of temporary plastic tapes at edges and ends of the road markings is also a good practice in order to avoid over-paint of the road marking material. Plate no. 12 presents an example of such operation.

Screed Machine

For larger scale works which involve application of long continuous marking lines (e.g. > 200m), adoption of screed machines tends to be a more efficient option. The screed machine application approach has the advantages of better control in operation speed (i.e. the evenness of marking thickness) and being able to keep the line in good position. The screed machine is self-propelled with thickness adjustment provision, it can move at a constant speed and is equipped with automatic glass beads dispensing units to facilitate even distribution of glass beads. Refer to Plate no. 13 for the details of the

machine.

In using the screed machine for road marking application, the operators should be conversant in using the directional pointer for keeping the markings in good alignments (see Plate no. 14).

3.3.6 Dispensing of Glass Beads

The performance of road markings with drop-on glass beads dispensed by hand depends on workmanship, quality and quantity of the materials employed. A glass bead distribution rate of 400-500 g/m^2 tends to be the most popular rate used in overseas countries. While an inadequate distribution rate would produce insufficient retro-reflectivity, an excessive rate would render the reflected light being shadowed by the excessive glass beads. The glass beads should also be applied evenly on the road marking surface.

Non-reflectorisation can also be caused by dropping beads onto very hot (230^oC) material since the beads would sink into the material under this situation. On the other hand, if the temperature of the material is too low, the beads will not adhere to the film and will be rapidly eroded away by traffic and weathering.

An alternative way for better dispensing of glass beads involves a hand push trolley with a rotating drum, from which the amount of glass beads dispensed on the marking is controlled by the traveling speed of the trolley (Plate 15). Plate 16 presents the combined usage of the screed machine and the glass beads dispensing trolley during a road marking operation.

As the skill of dispensing glass beads and other factors such as presence of gust and rain may have significant impact on the final retro-reflectivity of the road markings, some contractors may encounter difficulties in reaching the specification requirements for the full length of the road marking. Hence, one of the useful options is to add a certain amount of high performance glass beads (i.e. Refraction Index = 1.7 or 1.9) for performance compensation. Previous experience indicates that adding about 10% high performance glass beads by weight to the traditional glass beads generally produces good performance in terms of retro-reflectivity.

3.3.7 Removal of Thermoplastic Road Markings

Grinding method is the most effective method for removing thermoplastic materials, due to its quick and simple operation. There are two common types of grinding machines: the grinder which moves in a circumgyrate centrifugal motion (Plate no. 17) and the one with pure scarifying motion (Plate no. 18). The former machine works faster in the removal of thermoplastic materials and shatters the marking into bigger pieces.

For the removal of road marking materials on asphalt surfaces with certain texture depth, it remains unsolvable for completely removing the marking material stuck inside the macro texture. If complete removal of the marking material is a must, it is necessary to grind away the top layer of the pavement including the road markings and then resurface the pavement.

Although grinding method is an effective method for removing thermoplastic materials, the construction noise generated renders marking removal works hardly be arranged over certain parts of the road network. Alternatively, thermal patcher can be used to soften the thermoplastic road markings, allowing shoveling off easily. This alternative operation is relatively quiet and convenient for removing thermoplastic road markings of excessive thickness without damaging the existing road surface.

3.3.8 Masking of Road Markings

If resurfacing the pavement is undesirable, the grinding operation should not damage the existing pavement surface. After grinding away the existing road marking material and thorough cleaning of all small debris on the road surface, the remaining markings inside the voids of the pavement structure should be covered up with masking material.

The masking material should be dark colour thermoplastics, cold plastics or anti-skid dressing because they are more durable than paint under normal traffic conditions. Paints, even of the matt type, should not be used as masking material as it will be worn away in short period of time and expose the obsolete road markings underneath. Anti-skid dressing is more durable and looks comparatively matt in colour. Its glaring effect under wet conditions is lesser as compared to dark thermoplastic. However, it takes

longer time to apply. When choosing masking materials, individual site situation and purposes of the masking should be duly considered.

The colour of the masking material should match the colour of the existing road surface. The masking material must be free of intermixed glass beads to avoid the retroreflective effect, and should provide adequate skid resistance (at least 45 SRT). The finished surface of the masking should not be higher than the adjacent road surface by 6 mm. In masking arrows or characters, the masking area should be a rectangle fully covering the arrow/character.

The masking up method can avoid the expensive and time consuming operation of resurfacing the pavement. However, when the masking material aged, there may be a slight colour difference. Further, the thickness of the masking material above the pavement surface will cause a slightly uneven road surface at the masking areas. Project engineers should choose between resurfacing the pavement and the masking up method according to individual site situations.

3.3.9 Repainting of Thermoplastic Road Markings

Existing road markings to be renewed using similar type of material shall be roughened and any loose debris generated from the operation should be thoroughly cleared in order to ensure the substrate is reasonably sound. Either entire overlay of the new thermoplastics on the old ones or partial removal of the existing markings is allowed as long as the total thickness of the final marking does not exceed 6 mm.

3.3.10 Performance Tests for Road Markings

The ability of reflecting vehicle headlamp light (i.e. retro-reflectivity), luminance, thickness and skid resistance are the most important properties for road markings. Handheld retroreflectometer (Plate no. 19) can be used to measure retro-reflectivity and luminance of road markings. Skid resistance can be measured by British Pendulum (Plate no. 20) which is a static instrument with its rubber slider swinging over a wetted surface. Both devices are portable, quick and easy to set up on site. Several key aspects to assure consistency and accuracy of the measurement are illustrated in Table 4.

Table 4: Important Aspects for the Usage of the Road Marking Measuring Devices

Measuring Device	Aspects to be Aware of
Retroreflectometer	The road marking surface must be dry and clean. Any excessive glass beads on the road marking surface should be thoroughly cleared. The measurement can be affected by sunlight, hence appropriate shielding should be provided between the base of the device and the road marking surface. Calibration must be carried out each time before the device is used on site. Annual calibration is required subject to manufacturer's recommendation.
British Pendulum Tester	Annual calibration is required subject to manufacturer's recommendation. The gradient of the road under operation should not exceed 1 in 10 (uphill or downhill). Otherwise, it would reduce the accuracy of measurements. Special attention should be paid for the condition of the rubber slider. The slider should be replaced if any sign of deterioration is observed.

The measurement of thickness on new thermoplastic road markings shall be conducted in accordance with BS 3262 Part 3.

A set of sample particular specification for road markings is attached at Appendix 1.

3.3.11 Common Defects

The common defects of thermoplastic road markings and the associated possible causes are illustrated in Table 5.

Table 5: Defects and Possible Causes of Defects

Defects	Possible Causes
Blackening of markings	• Softening point of material is too low • Contamination by tyre rubber and oil
De-bonding / Flaking-off	• Dusty and unclean road surface • Low pavement surface temperature • Moisture in existing pavement • Defective material • Cracking of material • Insufficient binder content
Pinholes / Bubbles in markings	• Moisture in existing pavement • Material laid on uncured concrete • Overheated material
Flowing marking (i.e. no distinctive edge)	• The temperature of material is too high
Cracks in marking	• Thermal stress from overheating • Low temperatures or large seasonal temperature range • Material applied too thin • Uneven road marking thickness • Insufficient binder content
Shiny, glossy marking	• No or insufficient glass beads or the glass beads are too deeply embedded
Cratered marking	• Poor adhesion of glass beads and being popped out • The temperature of material is too low
Splattering	• Temperature of material is too high or too low
Discolouring (greenish yellow appearance)	• Material has been heated by scorching • Material reheated too many times or material has been overheated

Defects	Possible Causes
Discolouring (dull white colour)	• Material has been heated by scorching • Material reheated too many times or material has been overheated • Yellow thermoplastic not completely removed before white is added to the application pots • Insufficient content of titanium dioxide to resist UV light
Lumps in marking	• Material is either overheated or under heated

4. SITE SAFETY

4.1 Maximum Safe Heating Temperature

The most common mal-practice is the overheating of thermoplastic material to temperature levels above the "maximum safe heating temperature". Some extreme cases of heating the material to approximately 300^{o}C were noted in the past. This would cause explosions of the mixing drums due to gas expansion, which may lead to flying out of drum cover or other mechanical parts. Therefore in general, the recommended mixing temperature should be kept to 10-20^{o}C below the maximum safe heating temperature and such temperature level should be clearly marked on the containers of the thermoplastic material.

4.2 Examination of Plant and Equipment

All plant and equipment should be regularly examined for defects and malfunctions. The frequency of examination depends on the frequency of use of the plant or equipment and the conditions in which it is used. Moreover, it is necessary to check that equipment and safety devices (i.e. thermostat system and temperature gauge, etc) are correctly installed and in good working condition each time before heating of the thermoplastic material.

4.3 Treatment of Burns

Under the cases of burn-type injuries, immediate treatment can often prevent permanent injury to the victims. It is important to flood the affected part of the injured person's body with cold water immediately until the thermoplastic is cold. Do not try to wipe the thermoplastic off otherwise further injury may be caused. The injured person should be sent to hospital and the medical staff should be informed of the nature of the product.

4.4 Fire

If the maximum safe heating temperature is exceeded, there is a likelihood of fire when fume from the binders is ignited by the burner. Do not use water to extinguish the fire, use powder or foam extinguishers. Appropriate emergency equipment such as fire extinguishers, buckets of dry sand and first aid kit should be provided for handling emergency situations, and they should be properly maintained and regularly checked for proper performance.