Characteristics of retroreflective materials used in traffic control devices

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The present paper discusses the characteristics of various retro-reflective materials used in traffic road marking paint, road studs, and road signs. Glass beads of refractive index 1.50, 1.65 and 1.90 are commonly used for this purpose.

One of the major tasks involved in driving is identification of the object/road sign and to do the manoeuvring in different situations to avoid accidents. Whole of the task has to be performed within one or two seconds. For vehicle safety, Indian Roads Congress (IRC) has recommended the minimum safe stopping sight distance required for vehicles moving with 40 and 80 km/h as 30 and 120 m, respectively. In tackling complicated situations on road, it is necessary that the object should be visible from a longer distance. The visibility of the object depends upon the luminance level, conspicuity of the object, shape, size, contrast with background and colour. Efforts to improve visibility are continuing since 1921, when first white stripe was painted in Wayne county in USA. But, the painted stripes are worn off by traffic within one month.

Later on, good visibility was obtained by using glass beads of different sizes and refractive index in road markings. The glass beads of certain characteristics and under certain conditions catch the light from the source and reflect it back. This principle of retro-reflection improves the visibility of the ordinary paint film or studs. In the present paper, the characteristics of some of the control devices such as thermoplastic reflecting paint, reflecting sheets and studs is discussed which are presently in use for fabricating various traffic control devices and also the role of reflecting materials in avoiding the road traffic accidents.

Phenomenon of retroreflectivity

The phenomenon implies backward return of reflected light. The light beam enters the glass bead, and can bend or refract downward. This beam shines the back surface of bead having a paint containing TiO$_2$ acting as a white colouring matter. The white paint at the back helps the glass bead to act as a mirror. This condition of refraction is only satisfied when the glass beads are transparent, spherical and properly imbedded in the paint film. The optimum imbedment of glass beads in the paint film of thickness 0.007-0.010 inch is between 50 to 60% for better retro-refraction. Thus, the glass bead of proper size can only be embedded in a particular thickness of paint film. The bending of light is controlled by refractive index (RI) of the glass beads. The higher the RI, the greater would be bending of light. More the RI, more would be the return of light and brighter would be the line. In general, glass beads act as a magnifying lens. It is the chemical composition of the glass beads which determines RI. The glass beads of RI 1.50 have high silicon content. The glass beads of RI 1.90, are more transparent and do not contain silica or calcium. The manufacturing process of glass bead of RI 1.90 is very complicated, so the cost is more. Moreover, their density is also higher than other glass beads. The use of glass beads of RI 1.90 increases the cost of traffic control devices. The most commonly used glass beads for traffic control devices are of RI 1.50 and 1.65 beads. The process of retroreflectivity through glass beads has considerable potential to improve visibility of the paint and road signs even under unlit conditions.

Type of traffic control devices used in improving night time visibility

The main purpose of all the traffic control devices like road signs, markings, delineators, studs, bollards, etc., is to guide the motorists on road. There were 4500 fatal accident in 1961 increasing to 60000 in 1991. The reflective materials improve the conspicuity and legibility of the road signs and markings especially at crucial time of night. The early deduction of obstruction on road can avoid accident and can improve road safety. The safe stopping distance required for motorist at various speeds is
There is a need of a retroreflective based material, which does not allow any diffusion of light and reflects back most of the light received by it to the driver’s eye. This process is performed by glass beads of proper size embedded properly in the traffic paint.

Thermoplastic road marking material with a life more than 3 years was developed and made reflective by adding glass beads. The use of this reflective paint has started in India. The visibility of the control lines is improved considerably by adding glass beads. Thermoplastic material is a mixture of resins, glass beads, pigments and fillers in different proportions. The various properties of thermoplastic materials are given in Table 2. There are two methods of improving reflectivity of a paint: (i) by premix method, and (ii) drop on method. The grading of the glass beads by premix method and the drop on method are given in Tables 3 and 4.

Characteristics of reflective sheets

The reflective sheets are bright, durable, flexible and retro-reflective, which are designed for the production of various control devices. The sheets consist of tiny spherical lens (glass beads of size 80 μm.) adhered to a synthetic resin and encapsulated by flexible transparent plastic that has a smooth outer surface, and sold in the market in the form of rolls. These sheets are having either heat-activated or pressure-sensitive adhesives protected by removable thin layer of paper. The various properties of reflective sheets are given in Table 5 and retro-reflective characteristics are given in Table 6. The production of such sheets has not yet started in India.

Characteristics of retro-reflective raised pavement markers

The most commonly used raised pavement markers are cat’s eye and reflective studs which improve the road safety by making reflectorised road markings as
a permanent marking on the road. These studs are commonly used on centerline, road edges, speed breakers, narrow bridges, etc. Studs/Cat's eye are made up of aluminium or plastic body having single or double reflecting face with a slope of 30° from the base and a hole in the centre. The studs are fixed on the surface of the pavement by a nail. The recommended distance between two studs is 3 m.

In order to maximise the brightness level, two reflective faces of prismatic acrylic shell or polystyrene shell with an angle 10-30° are used. The angular surface does not allow any dirt collection over it. The plastic face also does not allow any damage of braking/scratching of the markers due to overloaded trucks. The various properties and coefficient of retro-reflectivity and compressive strength are given in Tables 7-8.

**Conclusions**

The use of retro-reflecting materials in the area of traffic control devices in India is not as popular as in the other countries and the manufacturing of glass beads of proper grading, refractive index and quality has not yet started in India. As a number of corridors of road systems in India are being designed for high speed traffic, the need of reflecting traffic control devices would increase day by day and it is right time to start their production. So, the development of these materials would save our foreign exchange resources. Reflective materials have positive benefits in the area of traffic safety under poor visibility conditions.

**References**

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