

Comparative Analysis of Pavement Marking Material based on Retro-Reflectivity

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Abstract - This research presents a comparative study of pavement marking materials including thermoplastic and water based glowmark compound based on the performance evaluation parameter. The performance evaluation parameter that is to be considered in the proposed work is retro-reflectivity. The factors affecting the performance evaluation parameter of pavement marking material were also evaluated. The pavement marking material were selected from seven different test sites located in Chandigarh region of India. These test sites were selected on the basis of type of material and further age of marking material. The performance evaluation results shows the effectiveness of particular material used in terms of age of the marking materials. In addition, it is also predicted which material is economic or cost effective for the particular roads.

Key Words: Thermoplastic, Glowmark, Retroreflectivity, Luminance, Durability.

1. INTRODUCTION

Road surface marking is a type of material or device which is used on a surface of road so as to convey driving information. These material can also be applied in other facilities used by vehicles to mark parking spaces or designate areas for other uses.

The markings assist the driver in detecting geometric changes downstream, support passing and merging manoeuvres and delineate safe travel boundaries for the driver. These markings play a critical role in the driving task under short, medium and long-range detection distances [4].

Road surface markings are used on paved roadways to provide guidance and information to drivers and pedestrians [27]. Uniformity of the markings is an important factor in minimizing confusion and uncertainty about their meaning, and efforts exist to standardize such markings across borders [27]. However, countries and

areas categorize and specify road surface markings in different ways.

1.1 Types of Pavement Marking material

To meet the objective of proposed work it is desirable to understand the types of pavement marking materials that are used on the roads of India and that are considered in the proposed work.

1.1.1 Thermoplastic

One of the most common types of road marking based on its balance between cost and performance longevity, thermoplastic binder systems are generally based on one of three core chemistries: hydrocarbons, rosin esters or maleic modified rosin esters (MMRE). Thermoplastic is composed of four main ingredients: binder, glass beads, titanium dioxide, and calcium carbonate (or filler). The binder is used to hold the mixture together as a rigid mass, the glass beads are used to provide reflectivity, the titanium dioxide is used for reflectivity enhancement, and calcium carbonate or sand is used as an inert filler material. Typical thermoplastic markings are 15 to 33 percent binder, 14 to 33 percent glass beads, 8 to 12 percent titanium dioxide, and 48 to 50 percent filler [24]. Thermoplastics have excellent durability on asphalt surfaces, which can be attributed to the thermal bonding mechanism between the heated thermoplastic and the asphalt surface upon installation, resulting in bond strengths equivalent to that of the cohesive strength within the asphalt. On the other hand, thermoplastics have poor durability on concrete surfaces due to the inferior mechanical bond between these two materials during installation, leading to premature failure on concrete surfaces [11].

Thermoplastics generally have more retroreflectivity than that of the traffic paints especially under night and wet conditions. They have an average service more than that of the paints [23].

1.1. 2. Glow mark Water based road marking compound

Is a water based road marking compound intended to meet the growing needs of traffic engineering and to provide improved safety measures in modern control systems[16].

1.2 PERFORMANCE EVALUATION PARAMETERS

1.1.2 Retro Reflectivity:

For markings to be visible at night they should be retroreflective unless ambient illumination ensures adequate visibility [22]. Retro reflectivity makes pavement markings visible to drivers at night. Measurement of retro reflectivity assesses the ability of an object to reflect light to a source in the same direction from which the light originally struck the object [10].

1.2.2 Durability:

Durability refers to the amount of material remaining on the pavement surface over time. Durability affects both the day time and night time appearance of markings. Durability performance is often measured either by determining the percentage of material remaining on the surface or by directly testing the bond strength of a material to the surface.

1.2.3 Luminance:

Luminance is the luminous intensity or brightness of any surface in a given direction, per unit of projected area of the surface as viewed from that direction, independent of viewing distance. The SI unit is candela/m². Pavement marking luminance is directly proportional to the amount of the light energy that is retroreflected by the marking toward a driver's eyes.

2. DATA COLLECTION AND DATA ANALYSIS

From literature review carried out it has been revealed that numerous factors affect pavement marking reterorefectivity and Luminance such as traffic, thickness, marking age, type of material used for road marking and environmental conditions. This study uses pavement marking data collected in the north region of India , to analyze factors effecting the performance of pavement marking material on the roads of Chandigarh which are pre selected based on age and type of marking material used.

Data is collected in terms of night time reflectivity and thickness from the various roads of thermoplastic and water based paint that were preselected based on age and type of material.

The value of reflectivity and thickness were recorded from various pre selected test sites for thermoplastic and are plotted against each other. In this section, the data is analysed in terms of the tables are drawn showing the

value of reflectivity at particular thickness and graph are plotted in between two for each test site individually towards central verge, at centre Line and Opposite central Verge for thermoplastic.

Water based paint have thickness in microns so it is considered to negligible approx. so there is only reflectivity reading is collected from the site where water based paint were laid.

3.1 Reflectivity Vs Thickness at sector 42 (Newly Laid Thermoplastic)

At sector 42, the pavement marking material were newly laid and the value of thickness and reflectivity are shown in table 1, table 2 and table 3 and their related plots are shown in figure 1, Figure 2 and in figure 3 for towards centre line, centre line and edge line towards shoulder individually.

Table 1 Reflectivity vs. Thickness towards central verge measured at Sector 42

| RL, towards central verge | Thickness |
|---------------------------|-----------|
| 365 | 3.9 |
| 360 | 3.87 |
| 358 | 3.81 |
| 334 | 3.77 |
| 312 | 3.65 |
| 305 | 3.62 |
| 287 | 3.4 |

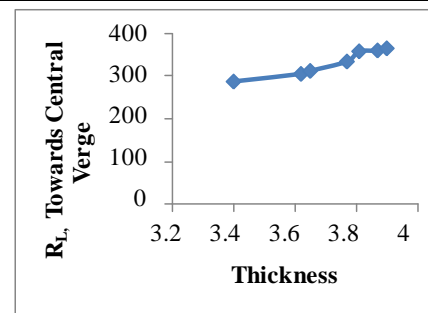


Figure 1 Reflectivity vs Thickness plot of Sector 42 towards central Verge

Table 2 Reflectivity Vs Thickness Values measured at central line at sector 42

| RL, Central Line | Thickness |
|------------------|-----------|
| 360 | 3.88 |
| 354 | 3.85 |
| 350 | 3.8 |
| 330 | 3.76 |
| 322 | 3.65 |
| 320 | 3.65 |

| | |
|-----|------|
| 280 | 3.56 |
|-----|------|

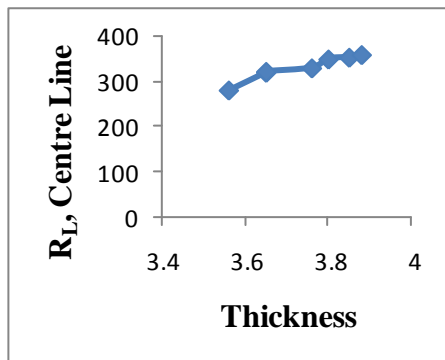


Figure 2 Reflectivity Vs Thickness Plot of sector 42 at Centre Line

Table 3 Reflectivity Vs Thickness Values measured on edge line towards shoulder at sector 42

| RL, edge line towards shoulder | Thickness |
|--------------------------------|-----------|
| 368 | 3.82 |
| 364 | 3.76 |
| 362 | 3.66 |
| 360 | 3.64 |
| 356 | 3.6 |
| 334 | 3.52 |
| 295 | 3.4 |

At Hallomajra Road, the pavement marking material were laid six monts ago and the value of thickness and reflectivity are shown in table 4, table 5 and table 6 and their related plots are shown in figure 4, Figure 5 and in figure 6 for towards centre line, centre line and opposite centre line individually

Table-4 Reflectivity Vs Thickness Values measured Towards central Verge at Hallomajra Road

| RL, Towards Central Verge | Thickness |
|---------------------------|-----------|
| 240 | 2.7 |
| 230 | 2.61 |
| 215 | 2.43 |
| 210 | 2.3 |
| 208 | 2.24 |
| 206 | 2.2 |
| 200 | 2.14 |

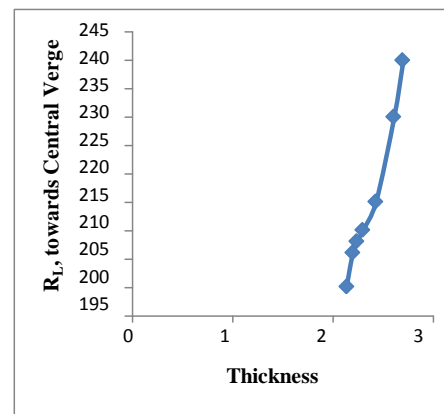


Fig- 4 Reflectivity Vs Thickness Plot at Hallomajra road Towards Central verge

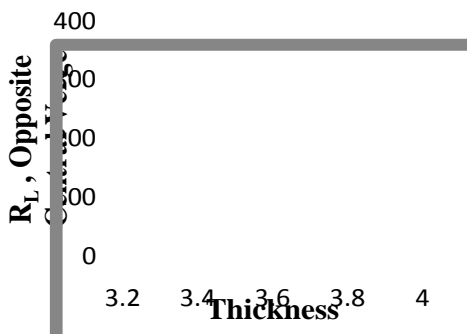


Figure 3 Reflectivity Vs Thickness Plot of sector 42

3.2 Reflectivity Vs Thickness at Hallomajra Road on which Thermoplastic were laid Six month ago

NOTE: The specific thickness was 2.5mm .however it is observed that freshly laid material is of higher thickness .Gradually when the traffic is made open the thickness reduces and approaches to specific thickness value of 2.5mm.

Table 5 Reflectivity Vs Thickness Values measured at central Verge at Hallomajra Road

| RL,Central Line | Thickness |
|-----------------|-----------|
| 202 | 2.63 |
| 181 | 2.55 |
| 175 | 2.53 |
| 170 | 2.52 |
| 165 | 2.5 |
| 80 | 2.45 |
| 70 | 2.4 |

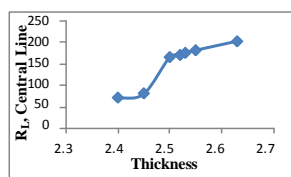


Fig-5 Reflectivity Vs Thickness Plot at Hallomajra road at Central Line

Table 6 Reflectivity Vs Thickness Values measured opposite central Verge at Hallomajra Road

| RL, edge line towards shoulder | Thickness |
|--------------------------------|-----------|
| 240 | 2.67 |
| 230 | 2.63 |
| 225 | 2.62 |
| 210 | 2.58 |
| 205 | 2.55 |
| 200 | 2.54 |
| 198 | 2.43 |

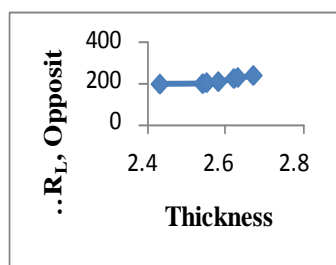


Fig-6 Reflectivity Vs Thickness Plot at Hallomajra road Opposite Central verge

3.3 Reflectivity Vs Thickness at Transport Chowk to Panchkula Road on which Thermoplastic were laid One Year ago:

At Transport Chowk to Panchkula Road, the pavement marking material were laid One Year ago and the value of thickness and reflectivity are shown in table 7, table 8 and table 9 and their related plots are shown in figure 7, Figure 8 and in figure 9 for towards centre line, centre line and opposite centre line individually.

Table 7 Reflectivity Vs Thickness Values measured Towards central Verge at Transport Chowk to Panchkula Road

| RL, towards central verge | Thickness |
|---------------------------|-----------|
| 180 | 2.39 |
| 178 | 2.37 |
| 177 | 2.36 |
| 174 | 2.34 |
| 170 | 2.31 |
| 167 | 2.26 |
| 160 | 2.22 |

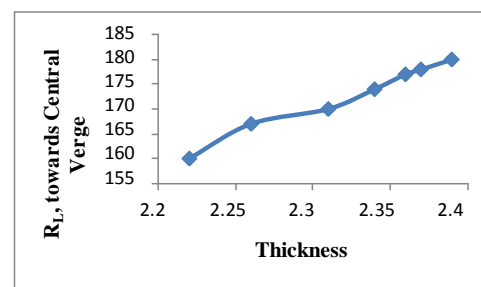


Fig-7 Reflectivity Vs Thickness Plot at Transport Chowk to Panchkula road towards Central verge

Table- 8: Reflectivity Vs Thickness Values measured at central Verge at Transport Chowk to Panchkula Road.

| RL,Central Line | Thickness |
|-----------------|-----------|
| 172 | 2.64 |
| 158 | 2.54 |
| 152 | 2.48 |
| 132 | 2.42 |
| 110 | 2.33 |
| 106 | 2.24 |
| 98 | 2.23 |

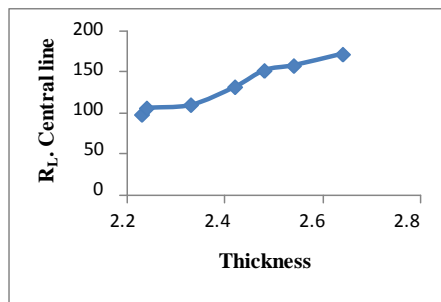


Fig-8 Reflectivity Vs Thickness Plot at Transport Chowk to Panchkula road at Central verge

Table- 9: Reflectivity Vs Thickness Values measured edge line towards shoulder at Transport Chowk to Panchkula Road

| RL, edge line towards shoulder | Thickness |
|--------------------------------|-----------|
| 260 | 2.67 |
| 256 | 2.54 |
| 230 | 2.44 |
| 217 | 2.37 |
| 211 | 2.34 |
| 209 | 2.33 |
| 187 | 2.23 |

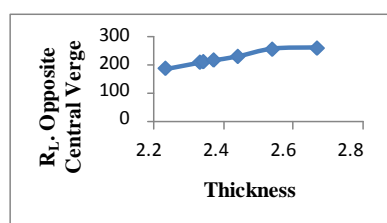


Fig-9 Reflectivity Vs Thickness Plot at Transport Chowk to Panchkula road edge line

3.4 Reflectivity Vs Thickness at Industrial Area to Panchkula Road on which Thermoplastic were laid Two Year ago:

At Industrial Area to panchkula road, the pavement marking material were laid two year ago and the value of thickness and reflectivity are shown in table 10, table 11 and table 12 and their related plots are shown in figure 10, Figure 11 and in figure 12 for towards centre line, centre line and opposite centre line individually.

Table 10 Reflectivity Vs Thickness Values Measured Towards central Verge at Industrial area to Panchkula Road

| RL, Towards Central Verge | Thickness |
|---------------------------|-----------|
| 94 | 2.24 |
| 92 | 2.22 |
| 90 | 2.16 |
| 84 | 2.15 |
| 83 | 2.13 |
| 82 | 2 |
| 81 | 1.98 |

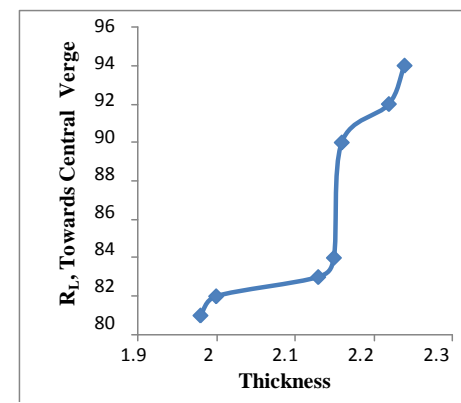


Fig-10 Reflectivity Vs Thickness Plot at Industrial area to Panchkula road towards Central verge

Table 11 Reflectivity Vs Thickness Values measured at central Verge at Industrial area to Panchkula Road

| RL,Central Line | Thickness |
|-----------------|-----------|
| 92 | 2.16 |
| 90 | 2.15 |
| 85 | 2.11 |
| 82 | 2.1 |
| 74 | 2.05 |
| 44 | 1.95 |
| 35 | 1.93 |

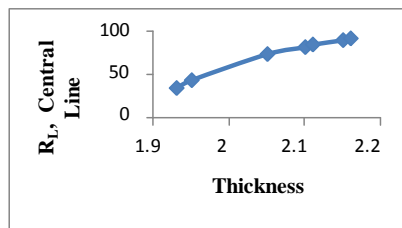


Fig-11 Reflectivity Vs Thickness Plot at Industrial Area to Panchkula road at Central verge

Table 12 Reflectivity Vs Thickness Values measured edge line towards shoulder at Industrial Area to Panchkula Road

| RL, edge line towards shoulder | Thickness |
|--------------------------------|-----------|
| 94 | 2.31 |
| 93 | 2.29 |
| 90 | 2.23 |
| 84 | 2.15 |
| 82 | 2.14 |
| 81 | 2.1 |
| 50 | 2 |

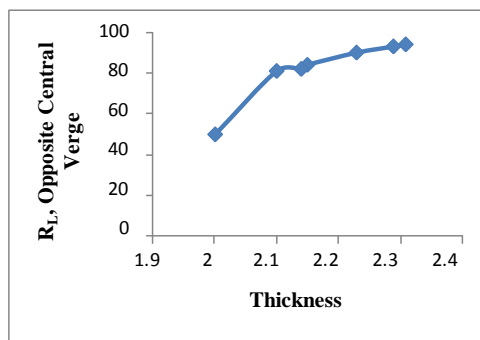


Fig-12 Reflectivity Vs Thickness Plot at Industrial area to Panchkula road at edge line towards shoulder

3.5 Reflectivity Vs Thickness at Transport Chowk to Tribune Chowk Road on which Thermoplastic were laid Three Year ago:

At Transport Chowk to Tribune Chowk , the pavement marking material were laid Three years ago and the value of thickness and reflectivity are shown in table 13, table 14 and table 15 and their related plots are shown in figure 13, Figure 14 and in figure 15 for towards centre line, centre line and opposite centre line individually.

Table 13 Reflectivity Vs Thickness Values measured towards central Verge at Transport Chowk to Tribune Chowk Road

| RL, Towards Central Verge | Thickness |
|---------------------------|-----------|
| 93 | 1.66 |
| 90 | 1.66 |
| 85 | 1.65 |
| 84 | 1.62 |
| 83 | 1.62 |
| 81 | 1.51 |
| 44 | 1.28 |

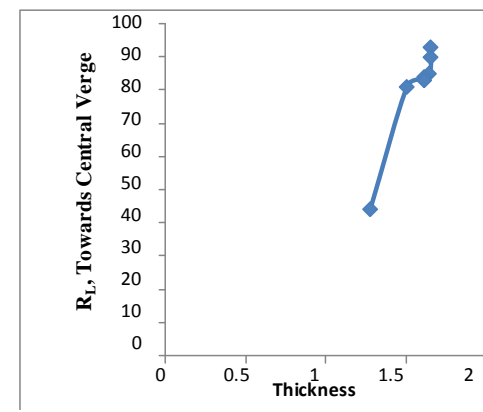


Fig-13 Reflectivity Vs Thickness Plot at Transport Chowk to Tribune Chowk road towards Central verge

Table 14 Reflectivity Vs Thickness Values measured at central Verge at Transport Chowk to Tribune Chowk Road

| RL,Central Line | Thickness |
|-----------------|-----------|
| 74 | 1.96 |
| 61 | 1.95 |
| 58 | 1.87 |
| 53 | 1.82 |
| 52 | 1.76 |
| 49 | 1.7 |
| 48 | 1.68 |

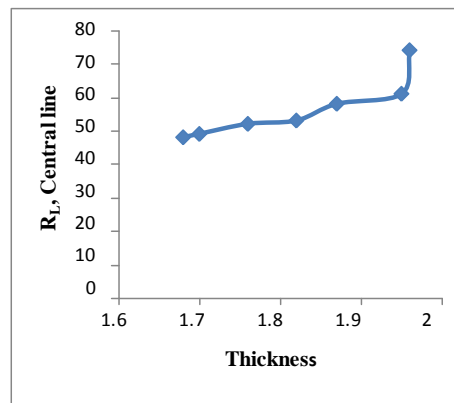


Fig-14 Reflectivity Vs Thickness Plot at Transport Chowk to Tribune Chowk road at Central verge

Table 15 Reflectivity Vs Thickness Values measured Opposite central Verge at Transport Chowk to Tribune Chowk Road

| RL, edge line towards shoulder | Thickness |
|--------------------------------|-----------|
| 94 | 1.95 |
| 91 | 1.9 |
| 87 | 1.83 |
| 85 | 1.8 |
| 82 | 1.76 |
| 70 | 1.74 |
| 54 | 1.66 |

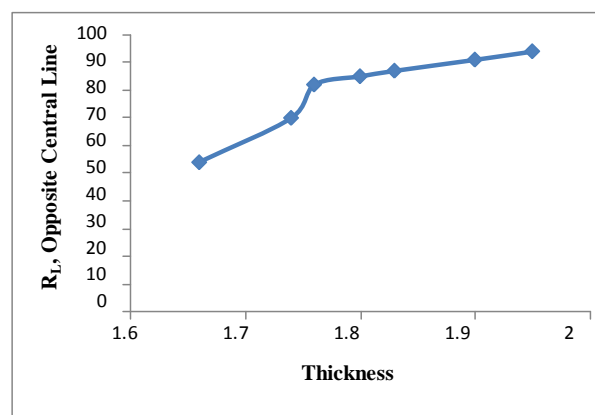


Fig-15 Reflectivity Vs Thickness Plot at Transport Chowk to Tribune Chowk road opposite Central verge

From all the plots drawn above based on data analysis, between reflectivity and thickness it has been shown that as the thickness of pavement marking material decreases the reflectivity also reduces.

3. RESULTS & DISCUSSION

Retroreflectivity, and thickness data collection was performed on selected locations (sites) on highways in the Chandigarh. The data collection was performed approximately after period six months, one year, 2 years and upto 3 years. Data analysis was performed using Microsoft Excel Data Analysis tool.

In the analysis, the following factors were considered that is traffic, pavement marking age, thickness, pavement marking material type and colour.

In this section the percentage change in the value of thickness and reflectivity with the age will be shown individually for each test site on which thermoplastic were laid towards centre line, at centre line and opposite centre line. Then the reflectance will be plotted against the age of material.

4.1 Variation in Reflectivity for thermoplastic

The variation in the value of reflectivity for each test site has been shown individually.

Difference in Reflectance after six months

Table 16 Difference of reflectance towards central verge after Six Month

| Reflectance lux/mcd/m ² | | | % Reduction | Average Reduction % |
|------------------------------------|---------|------------|-------------|---------------------|
| Zero days | 6months | Difference | | |
| 365 | 240 | 125 | 34.2465 | 34.7905 |
| 360 | 230 | 130 | 36.1111 | |
| 358 | 215 | 143 | 39.9441 | |
| 334 | 210 | 124 | 37.1257 | |
| 312 | 208 | 104 | 33.3333 | |
| 305 | 206 | 99 | 32.4590 | |
| 287 | 200 | 87 | 30.3135 | |

Table 17 Difference of reflectance at central verge after Six Month

| Reflectance lux/mcd/m ² | | | %Reduction | Average reduction % |
|------------------------------------|----------|------------|------------|---------------------|
| Zero | 6 months | Difference | | |
| 360 | 202 | 158 | 43.88889 | 55.71451 |
| 354 | 181 | 173 | 48.87006 | |
| 350 | 175 | 175 | 50 | |
| 330 | 170 | 160 | 48.48485 | |
| 322 | 165 | 157 | 48.75776 | |
| 320 | 80 | 240 | 75 | |
| 280 | 70 | 210 | 75 | |

Table 18 Difference of reflectance at edge line towards shoulder after Six Month

| Reflectance lux/mcd/m ² | | | % reduction | Average reduction% |
|------------------------------------|----------|------------|-------------|--------------------|
| Zero days | 6 months | difference | | |
| 368 | 240 | 128 | 34.78261 | 38.07495 |
| 364 | 230 | 134 | 36.81319 | |
| 362 | 225 | 137 | 37.8453 | |
| 360 | 210 | 150 | 41.66667 | |
| 356 | 205 | 151 | 42.41573 | |
| 334 | 200 | 134 | 40.11976 | |
| 295 | 198 | 97 | 32.88136 | |

Table 21 Difference of reflectance edge line towards shoulder after one year

| Reflectance lux/mcd/m ² | | | % Reduction | Average Reduction % |
|------------------------------------|-------|------------|-------------|---------------------|
| Zero Days | 1year | Difference | | |
| 368 | 260 | 108 | 29.34783 | 35.71002 |
| 364 | 256 | 108 | 29.67033 | |
| 362 | 230 | 132 | 36.46409 | |
| 360 | 217 | 143 | 39.72222 | |
| 356 | 211 | 145 | 40.73034 | |
| 334 | 209 | 125 | 37.42515 | |
| 295 | 187 | 108 | 36.61017 | |

Difference of Reflectance after One Year:

Table 19 Difference of reflectance towards centre verge after one year

| Reflectance lux/mcd/m ² | | | % Reduction | Average reduction % |
|------------------------------------|----------|------------|-------------|---------------------|
| Zero days | One Year | difference | | |
| 365 | 180 | 185 | 50.68493 | 47.81613 |
| 360 | 178 | 182 | 50.55556 | |
| 358 | 177 | 181 | 50.55866 | |
| 334 | 174 | 160 | 47.90419 | |
| 312 | 170 | 142 | 45.51282 | |
| 305 | 167 | 138 | 45.2459 | |
| 287 | 160 | 127 | 44.25087 | |

Difference of Reflectance after Two Year:

Table 22 Difference of reflectance towards centre verge after two year

| Reflectance lux/mcd/m ² | | | %Reduction | Average Reduction % |
|------------------------------------|--------|------------|------------|---------------------|
| Zero Days | 2 year | difference | | |
| 365 | 94 | 271 | 74.24658 | 73.81298 |
| 360 | 92 | 268 | 74.44444 | |
| 358 | 90 | 268 | 74.86034 | |
| 334 | 84 | 250 | 74.8503 | |
| 312 | 83 | 229 | 73.39744 | |
| 305 | 82 | 223 | 73.11475 | |
| 287 | 81 | 206 | 71.777 | |

Table 20 Difference of reflectance at centre verge after one year

| Reflectance lux/mcd/m ² | | | % Reduction | Average reduction% |
|------------------------------------|----------|------------|-------------|--------------------|
| Zero days | One Year | Difference | | |
| 360 | 172 | 188 | 52.22222 | 60.26777 |
| 354 | 158 | 196 | 55.36723 | |
| 350 | 152 | 198 | 56.57143 | |
| 330 | 132 | 198 | 60 | |
| 322 | 110 | 212 | 65.83851 | |
| 320 | 106 | 214 | 66.875 | |
| 280 | 98 | 182 | 65 | |

Table 23 Difference of reflectance at centre verge after two year

| Reflectancelux/mcd/m ² | | | % Reduction | Average Reduction % |
|-----------------------------------|---------|------------|-------------|---------------------|
| Zero Days | 2 years | Difference | | |
| 360 | 92 | 268 | 74.44444 | 78.66502 |
| 354 | 90 | 264 | 74.57627 | |
| 350 | 85 | 265 | 75.71429 | |
| 330 | 82 | 248 | 75.15152 | |
| 322 | 74 | 248 | 77.01863 | |
| 320 | 44 | 276 | 86.25 | |
| 280 | 35 | 245 | 87.5 | |

Table 24 Difference of reflectance at edge line towards shoulder after two year

| Reflectance lux/mcd/m ² | | | % reduction | Average reduction% |
|------------------------------------|---------|------------|----------------|-----------------------|
| zero | 2 years | difference | | |
| 368 | 94 | 274 | 74.45652 | 76.63964 |
| 364 | 93 | 271 | 74.45055 | |
| 362 | 90 | 272 | 75.13812 | |
| 360 | 84 | 276 | 76.66667 | |
| 356 | 82 | 274 | 76.96629 | |
| 334 | 81 | 253 | 75.7485 | |
| 295 | 50 | 245 | 83.05085 | |

Table 27 Difference of reflectance edge line towards shoulder after three year

| Reflectance lux/mcd/m ² | | | % Reduction | Average Reduction % |
|------------------------------------|--------|------------|----------------|---------------------------|
| Zero Days | 3years | Difference | | |
| 368 | 94 | 274 | 74.45652 | 77.07363 |
| 364 | 91 | 273 | 75 | |
| 362 | 87 | 275 | 75.96685 | |
| 360 | 85 | 275 | 76.38889 | |
| 356 | 82 | 274 | 76.96629 | |
| 334 | 70 | 264 | 79.04192 | |
| 295 | 54 | 241 | 81.69492 | |

Difference of Reflectance after Three Year

Table 25 Difference of reflectance opposite centre verge after three year

| Reflectancelux/mcd/m ² | | | % Reduction | Average Reduction % |
|-----------------------------------|--------|------------|----------------|---------------------------|
| Zero Days | 3years | Difference | | |
| 365 | 93 | 272 | 74.52055 | 76.01955 |
| 360 | 90 | 270 | 75 | |
| 358 | 85 | 273 | 76.25698 | |
| 334 | 84 | 250 | 74.8503 | |
| 312 | 83 | 229 | 73.39744 | |
| 305 | 81 | 224 | 73.44262 | |
| 287 | 44 | 243 | 84.66899 | |

Table 26 Difference of reflectance at centre verge after three year

| Reflectance lux/mcd/m ² | | | % Reduction | Average Reduction % |
|------------------------------------|--------|------------|----------------|---------------------------|
| Zero Days | 3years | Difference | | |
| 360 | 74 | 286 | 79.44444 | 82.99662 |
| 354 | 61 | 293 | 82.76836 | |
| 350 | 58 | 292 | 83.42857 | |
| 330 | 53 | 277 | 83.93939 | |
| 322 | 52 | 270 | 83.85093 | |
| 320 | 49 | 271 | 84.6875 | |
| 280 | 48 | 232 | 82.85714 | |

Discussion regarding the variation in Retro-reflectivity:

- From table 16, table 17 & table 18, it has been shown that the average decrease in the value of reflectance is 34.79% towards centre verge, 55.71% at centre line and 38.074% opposite centre verge after six month of marking material applied.
- From table 19, table 20 & table 21, it is determined that the average decrease in the value of reflectance is 47.81% towards centre verge, 60.26% at centre line and 35.71% opposite centre verge after one year of marking material applied.
- From table 22, table 23 & table 24, it has been shown that the average decrease in the value of reflectance is 73.81% towards centre verge, 78.66% at centre line and 76.6396% opposite centre verge after two year of marking material applied.
- From table 25, table 26 & table 27, it has been shown that the average decrease in the value of reflectance is 76.0195% towards centre verge, 82.99% at centre line and 77.073% opposite centre verge after three year of marking material applied.

4.2 Age of Pavement Marking Material

From the data collected from various preselected test sites the average reflectivity of thermoplastic material and age (in number of days) has been determined and the plot between the age and reflectivity has been drawn individually for towards centre line, at centre line and opposite centre line as shown below:

Table 28 Average Reflectivity Vs Age towards centre line

| Average Reflectance Towards Centre Verge | Age (in days) |
|------------------------------------------|---------------|
| 331.5714 | 0 |
| 237.8571 | 30 |
| 215.5714 | 180 |
| 172.2857 | 365 |
| 86.5713 | 730 |
| 80 | 1460 |

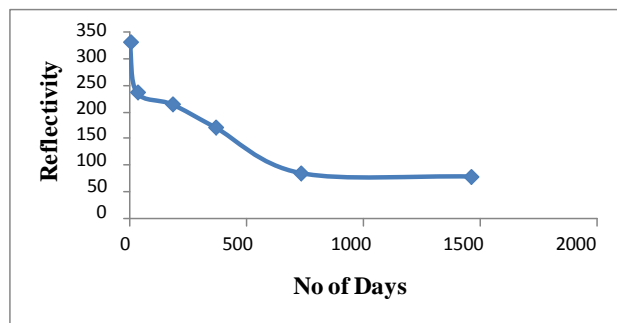


Fig-16 Average Reflectivity Vs Age towards centre line.

Table 29 Average Reflectivity Vs Age at Centre Line

| Average Reflectance at Centre | Age (in days) |
|-------------------------------|---------------|
| 330.8571 | 0 |
| 175.7143 | 30 |
| 149 | 180 |
| 132.5714 | 365 |
| 71.71429 | 730 |
| 56.42857 | 1460 |

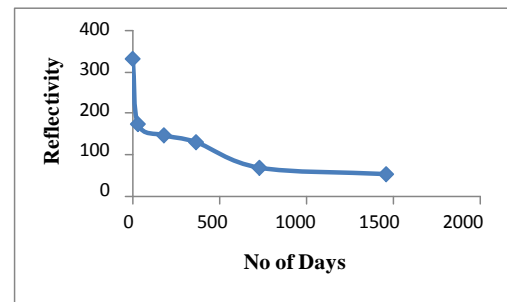


Fig-17 Average reflectivity Vs Age at Centre line

Table 30 Average Reflectivity Vs Age opposite Centre Line

| Reflectance at edge line towards shoulder | Age (in days) |
|-------------------------------------------|---------------|
| 348.4286 | 0 |
| 294.42 | 30 |
| 215.42 | 180 |
| 224.2857 | 365 |
| 82 | 730 |
| 80.42857 | 1460 |

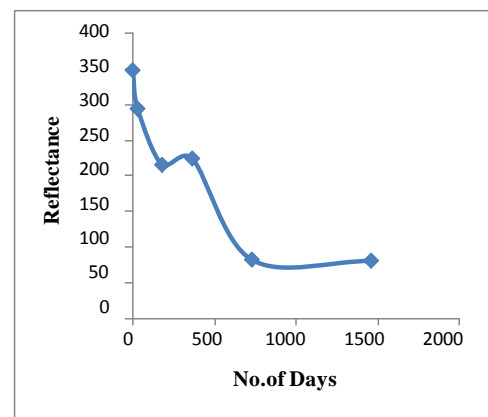


Fig-18 Average Reflectivity Vs Age opposite Centre Line

Discussion regarding Average Reflectance Vs Age of Thermoplastic:

- From figure 16, figure 17 and figure 18 it has been clearly indicated that as the time span of the applied material increases the reflectance decreases correspondingly.
- It affects more at centre line as compare to side lines as the time span increases as shown in table 28, table 29 and table 30.

4. CONCLUSION

Based on the performance evaluation results and the data analysis performed. The following conclusions are made :

- The value of retroreflectivity for water based paint was found to be less than the thermoplastic paint for same age.
- It was seen that the retero reflectivity of pavement marking decreases with age. For normal paints there is considerable decrease in the retero reflectivity within one year of application.
- Reflectivity of water based paint reduces more as compared to thermoplastic paint with time.
- It was also examined that the age of water based paint is approximately 15 months whereas thermoplastic paints have age more than three year.
- It is also concluded that water based paint should be applied on low traffic volume roads whereas thermoplastic should be applied on high traffic volume roads.
- On comparing reterorefectivity with thickness, analysis were performed by making XY plots which clearly shows that as the thickness decreases with time the reflectivity also decreases.
- The value of reflectivity decreases more at centre line as compare to side line because all the traffic plying at centre line. Thus it reduces thickness of marking material which in turn reduces the reflectivity.
- The average reduction in the value of reflectivity derived from data analysis in the time span of three years is approximately 77 % at side lines and 82.9 % at centre line for thermoplastic. And for water based paint it reduces almost 100%.
- It is also examined that the appearance of thermoplastic is excellent during initial time and its reflectivity is sustained throughout the service life and in case of water based paint its appearance is excellent during initial time but degrade after 14 to 18 months approx.
- It is also was seen that most of of the reduction occurs in one year after the application of the material after that there is some reduction in second year and almost negligible in third year.

REFERENCES

[1] Abboud, N. and Bowman B. L., "Cost-and longevity-based scheduling of paint and thermoplastic striping." Transportation Research

Record: Journal of the Transportation Research Board 1794(1): 55-62, 2002.

- [2] Al Masaeid Hashem R. and Sinha Kumars C., "Analysis of Accident Reduction Potential of Pavement Marking", Journal of Transportation Engineering, Vol 120, Page 723-736 1994.
- [3] Babic Darco, Mario M, Prusa Peter, "Evaluation of Road Markings Retoreflexion Measuring Methods" European Scientific Journal, Vol 3, pp 105-116, Feb 2014.
- [4] Burns, D. M., Hedblom T.P, and Miller T.W, "Modern Pavement Marking Systems: The Relationship Between Optics and Nighttime Visibility", Transportation Research Board Annual Meeting. Washington, D.C. Transportation Research Board. 2008.
- [5] Carlson P.J., Miles J., Chalmers S., "Strategy for Evaluating Durable Pavement Marking Materials for High Traffic Areas and Mountain Passes", Transportation Research Board, Washington, D.C., 2006.
- [6] Cho Yong, Kabassi Koudous, Pyeon Jae-Ho, Choi Kunhee, Wang Chao, and Norton Terri, "Effectiveness Study of Methods for Removing Temporary Pavement Markings in Roadway Construction Zones" Journal Of Construction Engineering And Management, Vol. 139, Page 257-266, March 2013.
- [7] Conglong Yu, "A Comparative Performance Analysis Of Pavement Marking Materials" Mississippi State University, Master Thesis, 2004.
- [8] Cuelho E., Stephens J., and McDonald C., "A Review of the Performance and Costs of Contemporary Pavement Marking Systems", Publication FHWA/MT -03-001/8117-17. Western Transportation Institute. 2003.
- [9] Dale, John M., "Pavement Markings: Materials and Application for Extended Service Life," NCHRP Synthesis of Highway Practice #138, TRB, Washington, D.C., June 1988.
- [10] Debaillon, C., and Carlson P.J, "Updates to Research on Recommended Minimum Levels for Pavement Marking Retroreflectivity to Meet Driver Night Visibility Needs", Report FHWA-HRT- 07-059, University of Iowa, pp - 46. 2007.
- [11] Gates, T.J., Hawkins H.G., and Rose E.R., Effective Pavement Marking Materials and Applications for Portland Cement Concrete Roadways. Texas Department of Transportation, Report No. FHWA/TX-03/4150-2, Year 2003.
- [12] Grath Mc, Marcia, A., "Durable Pavement Marking Materials Workshop". FHWA/TX-81-221, Federal Highway Administration, Washington, D.C., 1981.
- [13] https://en.wikipedia.org/wiki/Road_surface_marking.
- [14] <http://mutcd.fhwa.dot.gov/hm/2009/part1/part1a.htm>

- [15] Holman, F.L., "Glass Beads for Traffic Marking Paint," Alabama Highway Research, HPR Report #55, Alabama Highway Research, July 1971.
- [16] Jayanti Construction Limited manual.
- [17] John Lu Jian, Barter Tony, 'Evaluation Of Traffic Markings In Cold Regions', Journal Of Transportation Engineering , Vol 124, Page 42-51, January-February 1998.
- [18] Lee Dongmin and Donnell Eric T. , "Analysis of Night time Driver Behavior and Pavement Marking Effects Using Fuzzy Inference System", Journal of computing in civil engineering, May/June 2007.
- [19] Lee Hsiang Yi and Yuang Yu Chi , "Visibility Effectiveness of Hemisphere and Corner Cube Retro reflective Pavement Markers on Curved Roads", Journal Of Transportation Engineering, Vol 129, Page 77-83, January-February 2003.
- [20] Lee, J.T., Maleck T.L., and Taylor W.C, "Pavement Marking Material Evaluation Study in Michigan", ITE Journal, pp. 44-51, July 1999.
- [21] Lundkvist Sven-Olof, Isacson Ulf, Prediction Of Road Marking Performance, Journal Of Transportation Engineering , June 2007.
- [22] Migletz J., Graham J., "Long-Term Pavement Marking Practices", A Synthesis of Highway Practice, NCHRP Synthesis 306, NCHRP Synthesis of Highway Practice, Transportation Research Board, Washington, D.C., p. 162, 2002.
- [23] Migletz J., Graham J.L., Harwood D.W., Bauer K.M., "Service Life of Durable Pavement Markings", Maintenance of Transportation Pavements and Structures - Maintenance, Transportation Research Record, Transportation Research Board, National Research Council, Washington, D.C. , pp. 13-21, 2001.
- [24] Migletz, J., Graham J.L., Bauer K.M., and Harwood D.W. "Field Surveys of Pavement Marking Retroreflectivity." Journal of the Transportation Research Board, TRB, Transportation Research Record 1657, National Research Council, Washington, D. C., pp. 71-78, 1999.
- [25] Mull Dale M., and Sitzabee William E., "Paint Pavement Marking Performance Prediction Model", Journal Of Transportation Engineering, Vol. 138, Page 618-624, May 2012.
- [26] Ozelim Luana and Turochy Rod E., "Modeling Retro reflectivity Performance of Thermoplastic Pavement Markings in Alabama", Journal of Transportation Engineering, 2014, Page140.
- [27] Rehman SAU, Duggal A.K, " Suitability of different material used for Road marking- A Review", IJRET, Vol 2, Issue 2, May 2015.
- [28] Rumar K., Marsh D.K., "Lane Markings in Night Driving A Review of Past Research and of the Present Situation", University of Michigan, Ann Arbor, Transportation Research Institute, 1998.
- [29] Sitzabee William E., Hummer Joseph E., and Rasdorf William, "Pavement Marking Degradation Modelling and Analysis", Journal Of Infrastructure Systems, Vol 15, Page 190-199, September 2009.
- [30] Songchitruksa, Ullman Gerald L., and Adam M. Pike, "Guidance for Cost-Effective Selection of Pavement Marking Materials for Work Zones" Journal Of Infrastructure Systems, Vol 17, Page 55-65, June 2011.
- [31] Thomas, G.B. and Schloz C., "Durable, Cost-Effective Pavement Markings", Phase I: Synthesis of Current Research, Iowa Department of Transportation, Report No. TR-454. Available online:http://www.dot.ia.us/materials/research/reports_pdf/hr_and_tr/reports/tr454.pdf.
- [32] Traffic Engineering Manual, Ohio Department of Transportation (ODOT), 2002 Edition (including revision through January 20, 2006). Available Online:[http://www.dot.state.oh.us/traffic/Publication %20Manuals/TEM/TEM%20complete_012006.pdf](http://www.dot.state.oh.us/traffic/Publication%20Manuals/TEM/TEM%20complete_012006.pdf).
- [33] Zhang Guanghua, Hummer Joseph E., and William Rasdorf, "Impact of Bead Density on Paint Pavement Marking Retro reflectivity", Journal Of Transportation Engineering © Asce , Vol 136, Page 773-78 August 2010

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