International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 08 | Aug 2020 www.irjet.net p-ISSN: 2395-0072

Design of Cool & Reflective Pavements for Reduction in Air Temperature at Day Time & Better Visibility of Road at Night

Mr. Vidya Sagar[1], Mr. Honey Gaur[2]

[1]*M.Tech Scholar, Highway Engineering, Kalinga University, Naya Raipur- 492101, (C.G.) India*
[2]*Assistant Professor, Dept. of Civil Engineering, Kalinga University, Naya Raipur- 492101, (C.G.) India*

Abstract – *A pavement is a structure holding overlapped layers of processed materials above the natural earthen sub-grade. The pavement surface should be able to provide favourable light-reflecting characteristics. A Reflective & Cool Pavement is a kind of road surface layer that is light in colour as compare to the conventional dark pavement. This study aims to ensure that the dark colour of the pavement due to concrete, bitumen, tar and asphalt material is sufficiently be reduced so that it will reduce accidents at night due to visibility issues and reduce the air temperature of the road in the day time as well. This study gives an overview of pavement layers and their visible property. Various types of light-coloured road pavement, daytime luminance, night-time reflectivity on different types of roads and various benefits of light-coloured reflective road surfacing are to be studied in this subject. The urban temperature rises due to the effect of heat island in accumulation to the universal climatic variation, hence increases the temperature of heatwaves. Pavements in urban areas are made up of low reflective materials, which ultimately can attract a great amount of heat from solar radiation & then deliver it back to the surroundings. Pavements have become a significant contributor to this effect. Researchers have studied methods & techniques to reduce the urban heat and have acknowledged Cool & Reflective pavements as mitigation strategies. Using Cool & Reflective pavements helps to improve water quality, noise, safety, night-time illumination and reduces air temperature. It increases surface reflectance, which reduces the solar radiation absorbed by the pavement, increases permeability, which cools the pavement through evaporation of water and it provides a composite structure, which has been also found to release lower levels of heat at night. Roads become increasingly visible when using reflective pavements, which enhances traffic safety where normally dark areas exist both in rural and urban areas. Cool & Reflective pavements can be achieved by available materials. In this study, waste marble powder is used as a partial constituent in construction of cool rigid pavement. Such pavement is able to reduce peak surface temperatures by up to 3.2° C.*

Key words: *Cool & Reflective Pavements; Rigid Pavements, Urban Heat Island; White Topping; Reflective Admixtures; Marble Powder; Bright Colour Aggregates.*

1. INTRODUCTION

As we observe that Cities can be several degrees warmer than surrounding regions due to the built environment and the concentration of human activity, a phenomenon stated as an urban heat island (UHI). The major cause of the urban heat island phenomena is urbanization, whereby natural soft-scapes are replaced with dark hard surfaces such as Asphalt roads and Cement Concrete pavements that absorb and reradiate thermal energy again back into the atmosphere. Urban heat island causes a substantial rise in temperature in the urban areas during the summer. Therefore, the level of greenhouse gas emission gets higher causing air pollution. The increase in solar reflectance of the urban surface reduces its solar heat expansion, lowers the temperature and decreases the discharge of thermal infrared radiation into the atmosphere. Cool & Reflective Pavement minimizes summer heat islands and improves the environment. Few authors have worked on Cool & Reflective Pavements but the application is minimal. There are little exploration and policy recommendations for cool & reflective pavements in India.

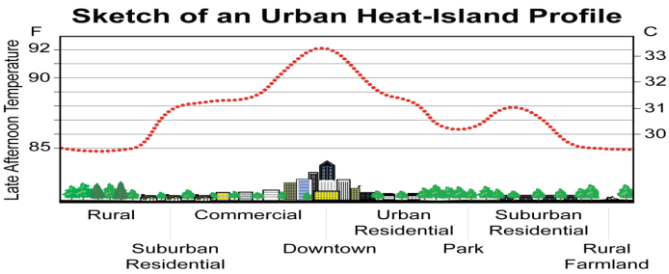


Figure 1.1: Urban Heat Island Profile

1.1 OBJECTIVE

The objective of this study is to analyse the behaviour of a cool & reflective pavement. All the roads in our country have dark grey coloured pavement, which turns into the nearly black coloured pavement especially when rain occurs at night. It is very much problematic for a driver to judge the road edge in such an adverse condition. Visibility of a driver also gets distracted due to glare of headlights of in-front coming vehicles; it is observed that potholes are also not visible clearly on the roads at night in absence of street lighting. It has also been seen that many animals are laid on the roads majorly at village areas but not clearly visible at night. These all lead to road accidents due to poor visibility of roads to the driver. Cool & Reflective behavior of a pavement comes about by the response given to the choice of construction materials and engineering design. The use of Cool & Reflective pavements is meant to reduce pavement temperature by increasing pavement reflectivity or controlling temperature by other means and increase the visibility of road at night with the selected techniques. This report gives

additional information on Cool & Reflective pavement technology and options for implementation. This study investigates the actual position on the field of cool & reflective pavements and proposes the operation for the use of cool & reflective pavements in India. In this paper, an attempt has been made to highlight the construction of new pavements.

1.2 FUNDAMENTAL OF COOL & REFLECTIVE PAVEMENT

The conventional dark top pavements contribute to global warming because they discharge heat into the air. Cool rigid paved areas are part of roadway development which can be used to direct urban heat island impacts. These decline heat being unimpeded out lately in afternoon & within the night time by 2 most important keys; extended emissivity & extended reflectivity. Few cool pavement progressions utilize both the characteristics by growing the reflection factor of traditional pavement; lesser the sun's critical heat. In this way, the heat moving from warm blacktops to surrounding air is manipulated by temperature convection & dispositions.

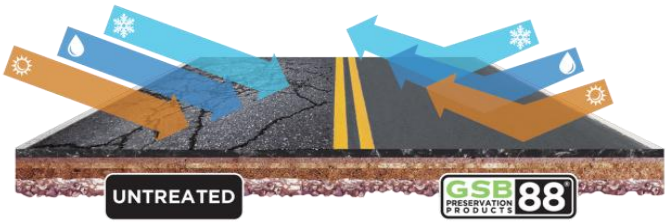


Figure 1.2.1: Low Heat Reflection from Dark Pavement

1.3 PRINCIPLE BEHIND COOL & REFLECTIVE PAVEMENT

Cool & Reflective pavement is a road surface that uses additives to reflect solar radiation, unlike conventional dark pavement. Conventional dark pavements absorb 70–90% of sunlight and warm the local air. Cool & Reflective pavements are made with different surfaces to increase albedo, thereby reflecting ultraviolet radiation out of the atmosphere. Increasing albedo reduces heat transfer to the surface and creates local Reflection. The existing dark roadway can be changed to increase albedo through white topping or by addition of reflective coats and seal coats. New pavement can be constructed to increase albedo by using modified mixes and permeable pavements.

2. PROBLEM IDENTIFICATION

Fast and improper development in urban areas is abnormally expanding because of the aspects to accomplish social requirements. Improper development or development without planning will create many difficulties, which are going to affect the health, quality & luxury of adjacent communities.

2.1 CURRENT ISSUES IN CONVENTIONAL PAVEMENT

➢ **Heat Resultant Issues at Day Time**

- Temperature rise due to dark coloured pavement.

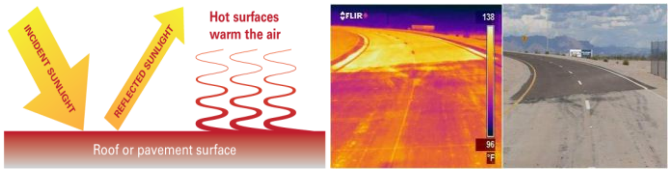


Figure 2.1.1: Hot Surface Warming Air (Left) & Comparison of Original & Infrared Picture Showing Heat Intensity (Right)

- Harmful and bad smells of melted petroleum products like bitumen, asphalt or tar road surface during summer season.
- Deterioration of Bituminous Seal Coat and Tack Coat of Pavement due to excessive heat in summer season, which tends to road damages.

Figure 2.1.2: Deterioration of Bituminous Seal Coat Due to Excessive Heat

2.2 CHANGING THE ALBEDO

The reflection or holding the daylight in any material is estimated in a unit less parameter known as albedo. Solar reflectance or Albedo is the percentage of solar energy reflected by any surface. Theoretically, albedo might stretch out between zero for dull indispensable, absorptive planes to one for gently shading intelligent planes. No articles can hold or redirect 100% of the sun's vitality exuded upon them, in this way, an albedo exactly zeros or one has never been seen on a characteristic thing. Albedo can be determined by using an apparatus known as a pyrometer. Pyrometer gauge is an electromagnetic radiation in objects of essentialness per square length. Table 1.1 provides some common albedo values for various surfaces.

TABLE 1.1: Common Albedo Value (EMERALD CITIES)

Fresh Asphalt	0.05	Fresh Grey Portland Cement	0.35
Black Soil	0.13	Desert Sand	0.40
Bare Soil (land)	0.17	Cool & Reflective Pavement Coatings	0.50
Aged Asphalt	0.20	Arctic Region	0.77
Green Grass	0.25	White Portland Cement	0.80

Aged Portland Cement	0.29	White Roof Coatings	0.88

Conventional concrete and bitumen pavements have an albedo between 0.05 to 0.40, which means it absorbs about 95% to 60% of the solar energy, which reaches them instead of reflecting it away. Further, the albedo of such surface changes with time due to aging and wear. The albedo of concrete pavements decreases over time due to accumulation of dust and traffic. In contrast, the albedo of asphalt increases with age and becomes more weathered as the binder oxidizes and wears away, exposing the aggregate.

2.3 POOR VISIBILITY AT NIGHT

- Poor Visibility Of Road Edges At Night
- Poor Visibility Of Road In Rainy Season At Night
- Poor Visibility Of Road Due To Glare Of Head Light Coming From In Front Vehicle
- Poor Visibility Of Pot Holes And Speed Breakers At Night
- Poor Visibility Of Animals Laid On The Road At Night
- Poor Visibility Of Any Object On The Road At Night

2.4 Classification of Cool & Reflective Pavement Surfacing

- Portland Cement Concrete Paving
- White Topping
- Asphalt Emulsion Sealcoats/ Asphalt Slurry Seals/ Asphalt Surface Coatings
- Resin Modified Emulsion Pavement
- Permeable Pavement

3. BENEFITS OF COOL & REFLECTIVE PAVEMENT

Cool & Reflective & Reflective payment is the concept based on the self-guiding road to the road users.

- **Provides Self guiding pavement**
- **Increase pavement surface reflectance**

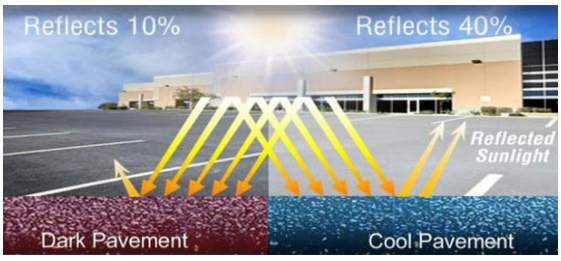


Figure 3.1: Heat Reflection from Dark and Cool Pavement

- **Night-time illumination**

Figure 3.2: Comparison of Night-time illumination of Dark & Light Coloured Pavement

- **Air Quality**
- **Stormwater Management**
- **Noise Reduction**
- **Safety**
- **Energy Conservation**

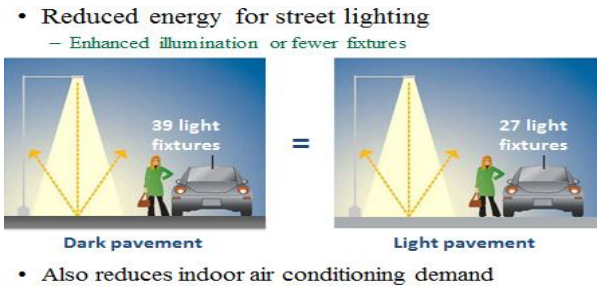


Figure 3.3: Energy Saving Comparison of Dark & Light Pavement

- **Pavement Durability**

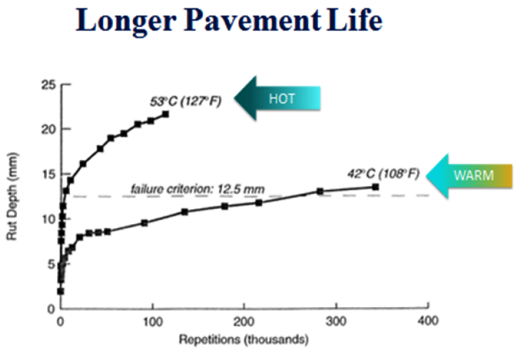


Figure 3.4: Pavement Durability Graph

- **Other Benefits**
  - Improved comfort and health.
  - Increased driver safety.
  - Improved air quality.
  - Reduced street lighting cost.
  - Reduced power plant emissions.
  - Improved water quality.
  - Reduction in rate of deterioration.

4. METHODOLOGY

➢ STRATEGIES FOR NEW CONSTRUCTION

To mitigate the heat island effect, Cool pavement strategies can be applied to new pavements or existing pavements. The cool pavement strategies are applied through removing and replacing of the pavement surface or overlaying the existing surface with a thick new surface.

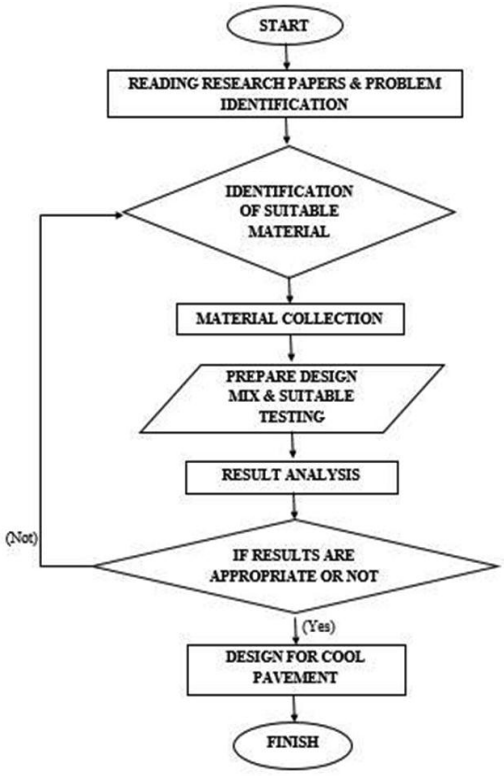
➢ STRATEGIES FOR EXISTING PAVEMENTS

Reconstruction and rehabilitation is performed on an as need basis. In cases where the existing pavement is in relatively good condition, the effective strategy is to apply a surface treatment to change the reflectivity of the pavement surface.

➢ Some of the cool paving techniques are:

- Modified Asphalt Pavement
- Modified Portland Cement Concrete
- Chip Seals
- Resin Based Pavements
- Porous Asphalt Pavements
- Porous Concrete Pavements
- Solar Harvesting
- Grass Paving
- Plantation of Shady Trees

4.1 WORKING METHODOLOGY FLOW CHART



4.2 Waste Material Production (Marble Powder)

There are several wastes being generated from the marble industry. The use of these wastes can be done for partial replacement of cement or other constituents of concrete. In developing country like India, marble is decorative & very popular construction material. If we talk about the waste marble powder, India is huge generator of it. It is estimated to have 3,127 thousands of tons of marble powder was formed in year 2009-10 in India **(Mittal et al. 2016)**. The waste marble powder is generated while the cutting procedure of marble stone. Letting these leftover resources out directly to the atmosphere can source environmental problems. Hence, use of marble powder in various construction practices would help to protect the atmosphere.

Besides above, OPC 43 is used with marble waste in this study.

4.3 EXPERIMENT PARAMETERS

The tests to be performed for this study work should strictly be done with proper procedure & accurate parameters.

Materials/Tests	IS Codes
Ordinary Portland Cement	IS 8112: 1989
Test for aggregate	IS 2386 (Part 1,2,3,4,5,6,7): 1963
Compression test	IS 14858: 2000
Slump test	IS 7320: 1974
Vicat's Apparatus	IS 5514: 1996
Le-Chatelier Device	IS 5514: 1996
Basic considerations	IS 456: 2007

4.4 TESTS ON MATERIALS

➢ Normal Consistency Test

The consistency of bond test pursues the IS 4031 (4) – 1988. The test for deciding consistency of cement was performed with Vicat's apparatus and consistency plunger. The water cement ratio was taken 25% by weight of cement. The measuring time must not be over 5 minutes & must not be less than 3 minutes to measure consistency. The niddle penetration should lie between 7 to 5 mm and that water rate is considered as consistency of concrete. Weight of cement taken is 400gm, water required is 100ml & the normal consistency (P) comes out to be 28%.

➢ Specific Gravity of Cement

Weight of Empty Dry Flask (W1)	= 68.00gm
Weight of Flask + Cement (W2)	= 170.00gm
Weight of Flask + Kerosene + Cement (W3)	= 230.00gm
Weight of Flask + Kerosene (W4)	= 142.00gm
Specific Gravity of Kerosene (Sk)	= 0.79

- **Specific Gravity of cement**

$$S_g = \left(\frac{W2 - W1}{(W2 - W1) - (W3 - W4) \times 0.79} \right)$$

= **3.14**

- **Specific Gravity of Coarse Aggregate**

Using the wire bucket, the specific gravity test for course aggregate was performed as per IS 2386 (3) – 1963.

Saturated aggregates in water with basket (W1)	= 1.745kg
Basket left in water (W2)	= 0.545kg
Saturated aggregate in water Ws = (W1-W2)	= 1.2kg
Soaked surface dry aggregate in air (W3)	= 2.125kg
Oven arid aggregate in air (W4)	= 1.93kg
Water equal volume of the aggregates (W3-Ws)	= 0.925kg
Specific gravity of aggregate = (W4/(W4-Ws))	=(1.93/.73)
	= 2.644

- **Initial & Final Setting Time**

The final & initial setting time test for cement follows IS : 4031(5) - 1988. The test for determining the initial and final setting time of cement was performed using Vicat's apparatus and setting time of Vicat's needles. The water must be added "0.85P" by mass of cement, where "P" is the consistency of cement.

4.5 PREPARING CONCRETE MIX DESIGN

For constructing rigid pavement the concrete design of M30 is to be prepared. The mix design is prepared as per IS10262:2019. Mix proportion was done by keeping the ratio (i.e. for the weight of the different samples) as 1:1.26:2.49 while the quantity of the different materials, which were used in mix proportioning, is shown in Table 4.1.

Stipulations for proportioning

1. Cement Type = OPC 43 grade
2. Size of Aggregate = 20 mm
3. Maximum Cement Content = 360 kg/m3
4. Marble Powder Content = 149 kg/m3
5. Type of Aggregate = Crushed Angular
6. Exposure Condition = Moderate

The materials that have been used in making M30 concrete mix were should be performed some basic tests in laboratory. The readings of the experiments conducted are specified in the table below.

Recorded test results for the materials to be used-

1. Type of Cement =OPC 43 grade
2. Maximum Nominal Aggregate Size =20 mm
3. Cement Content =320-360 kg/m3
4. Marble Dust Content =63.86-149 kg/m3
5. Type of Aggregate =Crushed Angular
6. Exposure Condition =Moderate

According to IS:10262 - 2019, the values for the target mean strength and characteristic strength after 28 days should be 38.25 MPa & 30 MPa respectively, as revealed in the table beneath.

Mix Proportioning for Target Strength-

Mean Target Strength	= 38.25 N/mm2
Characteristic Strength after 28 days	= 30 N/mm2

For making 1 m3 M30 mix the proportions that have been taken are mentioned below-

Mix proportions for 1 m3 of concrete (IS: 10262 - 2019)-

Mass of Cement	= 327.81 kg/m3
Mass of Marble Dust	= 140.49 kg/m3
Mass of Water	= 203.47 ltr
Mass of Sand	= 600.79 kg/m3
Mass of Coarse Aggregate 20 mm	= 695.77 kg/m3
Mass of Coarse Aggregate 10 mm	= 463.84 kg/m3
Water Cement Ratio	= 0.43

4.6 CHEMICAL CONSTITUENTS OF MARBLE POWDER & CEMENT

The composition is shown in the table 4.1 below-

Table 4.1: Chemical Constituents of Cement & Marble Powder (Tran et al. 2009)

Chemical Compound	Constituents of Marble Dust (%)	Constituents of Cement (%)
Calcium Oxide	55.10	30-58
Silica Dioxide	0.49	21-30
Magnesium Oxide	0.41	1.4-2.3
Iron Oxide	0.13	5.1-8.9
Aluminium Dioxide	0.18	-
Sodium Oxide	0.21	-
Potassium Oxide	0.07	-
Sulphur Trioxide	0.07	-

In above table 4.5, Silicon Dioxide (SiO2), Magnesium Oxide (MgO), Iron Oxide (Fe2O3), Aluminium Dioxide (Al2O3) do not get along the standard range of cement. Hence, marble powder is somewhat characterized as cement but not completely functioning as cement due to not having a binding property in it.

4.7 OPC (GRADE 43) TESTING

Various examinations on the cement (OPC Grade43) have been conducted in the laboratories so as to achieve or check the values as per the relevant IS codes. Indian Standard code that has been used for the testing of OPC is IS : 8112 - 1989. The results of the entire basic test for cement are as below-

Various test results performed on OPC-

Sr. No.	Name of experiment	Results
1.	Fineness	= 98.20%
2.	Specific Gravity	= 3.14
3.	Initial Setting Time	= 133 minutes
4.	Consistency	= 28%
5.	Final Setting Time	= 486 minutes
6.	Compressive Strength	= 25.57 N/mm2 for 7 days, 33.16 for 28 days.

4.8 COARSE AGGREGATE TESTING (CONVENTIONAL)

Several tests on conventional coarse aggregates (10-20mm) have been conducted in the laboratories so as to achieve or check the values as per the relevant IS codes. Indian Standard code that has been used for the testing of conventional coarse aggregates is IS : 2386 (Part 1, 2, 3, 4, 5, 6, 7) : 1963.

Various test results performed on conventional coarse aggregate-

Sr. No.	Name of experiment	Results
1.	Crushing Value	= 27.4%
2.	Toughness Test (Impact Value)	= 18.64%
3.	Flakiness & Elongation Indices	= 5.6% & 4.14%
4.	Abrasion Test (Hardness)	= 13.53
5.	Specific Gravity & Water Absorption Test	= 2.644 & 1.02%

4.9 COARSE AGGREGATE TESTING (WHITE COLOURED)

Several tests on brighter coarse aggregates (10-20mm) have been conducted in the laboratories so as to achieve or check the values as per the relevant IS codes. Indian Standard code that has been used for the testing of white coarse aggregates is IS: 2386 (Part 1, 2, 3, 4, 5, 6, 7) : 1963.

Various test results performed on white coloured coarse aggregate-

Sr. No.	Name of experiment	Results
1.	Crushing Value	=29.6%
2.	Toughness Test (Impact Value)	=19.34%
3.	Flakiness & Elongation Indices	=3.66% & 3.14%
4.	Abrasion Test (Hardness)	=14.36%
5.	Specific Gravity & Water Absorption Test	=2.56 & 1.04%

4.10 CEMENT – MARBLE POWDER (MIX) TESTING

Different important tests were conducted on the cement marble powder mix to check the behaviour of mix for different proportions.

Table 4.2: Compressive strength of cement marble powder mix

Sr. No.	%age of Marble Powder	Weight of Marble Powder in gm	Weight of Cement in gm	Compressive Strength (after 3 days) In MPa	Compressive-Strength (after 7 days) In MPa
1	15%	27.05	158.15	15.23	24.12
2	20%	36.60	149.26	15.47	24.66
3	25%	45.15	139.47	15.84	25.01
4	30%	54.20	130.63	16.07	25.57
5	35%	63.35	121.68	15.76	24.97

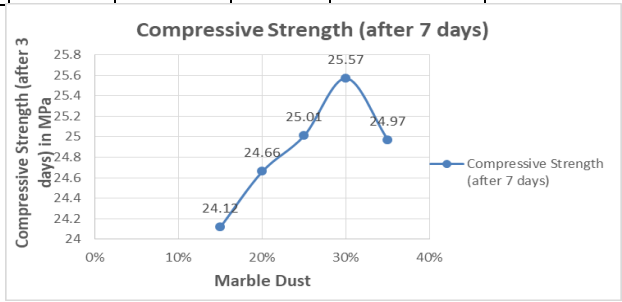


Figure 4.10.1: Variation in compressive strength (7 Days) with variation in amount of marble powder

After taking into consideration the values from upper table, it concludes that when we mix 30% of marble powder by weight of cement (i.e. 54.20gm), we achieved the highest values of compressive strength for 7th days. The value of compressive strengths rises with rise in marble powder amount up to 30% but it starts decreasing later.

5. RESULT & DISCUSSION

5.1 MIX DESIGN TESTING RESULT

The M30 concrete mix prepared with the addition of marble powder gives adequate results as per the values from IS : 10262 - 2019. The value for 28 days of compressive strength is 33.16 MPa as shown in table 5.1 below-

Table 5.1: Compressive Strength & Flexural Strength test outcomes on Mix Design

Mix	Cement (kg/m³)	Marble Dust (kg/m³)	Water (kg/m³)	Aggregate (kg/m³)	Sand (kg/m³)	Compressive Strength (MPa) (7 & 28 days)	Flexural Strength (N/mm2) (7 & 28 days
M 30	327.81	140.49	203.47	1159.61	600.79	25.57 & 33.16	3.54 & 4.03

The M30 concrete mix prepared with the addition of marble powder gives acceptable results.

5.2 TEMPERATURE DIFFERENCE READINGS

The temperature difference readings are taken for two conditions; (1) surface temperature readings & (2) inner pavement temperature readings as shown in below tables-

Table 5.2: Surface temperature reading for Conventional & Cool Pavement (at 12:00 PM)

Date	Temperature (°C)		Temperature Difference (°C)	% Reduction
	Cool Pavement	Conventional Pavement		
Mar 10, 2020	28.7	31.0	2.3	7.42
Mar 11, 2020	31.0	33.4	2.4	7.19
Mar 12, 2020	34.1	36.7	2.7	7.36
Mar 13, 2020	32.1	34.6	2.5	7.23
Mar 14, 2020	34.1	37.3	3.2	8.58
Mar 15, 2020	34.3	36.9	2.6	7.05

Table 5.3: Inner surface temperature reading for Conventional & Cool Pavement (at 12:00 PM)

Date	Temperature (°C)		Temperature Difference (°C)	% Reduction
	Cool Pavement	Conventional Pavement		
Mar 10, 2020	28.1	29.7	1.6	5.39
Mar 11, 2020	30.1	31.2	1.1	3.53
Mar 12, 2020	32.6	34.1	1.5	4.40
Mar 13, 2020	30.5	32.4	1.9	5.86
Mar 14, 2020	34.3	35.6	1.3	3.65
Mar 15, 2020	32.4	34.3	1.9	5.54

5.3 Discussion

From table 5.1, it is clear that the surface temperature difference is more than that of the inner temperature difference. This is due to the higher surface reflection factor of the cool reflective paved surface; hence, it reflects more sunlight as compared to that of the conventional dark top pavements. The average percentage reduction of surface temperature is 7.47%. On the other hand, the difference in the inner surface pavement temperatures of conventional and the cool pavement was found to be 4.73%. The main reason for such temperature difference is due to the utilisation of waste material, which provides an extra surface reflection factor as compared to the internal layers. Several tests were conducted for compressive as well as flexural strength of concrete mixed with marble powder. The results achieved were acceptable and show that the usage of marble powder as a fractional addition in concrete can work in terms of its strength.

6. CONCLUSION

6.1 GENERAL

Selecting marble powder as a waste material where it is generated the most in huge quantity is to be added in the construction of cool and reflective pavement was considered. Several tests were conducted to justify the mix of cement and marble powder. Using this technique for the construction of cool and reflective pavement has provided appropriate results in terms of the temperature difference of cool and conventional pavement. The ideas presented here are only meant as a sampling of the types of activities that could expand the knowledge and experience for Cool & Reflective pavements. As discussed above, these needs encompass not just technical pavement and construction research, but also institutional research and public information. The addition of some new material or the replacement of conventional materials will be a great contribution. Materials like white or grey coloured marble powder have shown great results when applied. Mixing these materials in design concrete and noticing the changes in temperature might lead to some new outcomes. According to this study, the process of mitigation of urban heat must have three phases; first, specifying the new reflective materials; second, developing those materials and third, applying those materials for positive results. Cool & Reflective pavement can reduce not only the air temperature but also, roads, roadside furniture & vehicle damage cost causing accidents due to poor visibility.

6.2 CONCLUSION

Light reflection is very closely related to visibility, safety and comfort-ability at the same time as traveling by any driver of the vehicle. It is therefore important to build up knowledge of light reflecting specifications of road pavements but also from the other road-building elements, like barriers, banks, middle or side conductors, foot and cycle paths, etc. in order to enhance visibility effects while designing for the future motorists for the good inhabitable environment. In this study, the mix design procedure is proposed by utilizing marble powder wastes as a partial replacement of cement in order to execute the excess heat from the outer surface as well as inner surface of the pavement. It was observed that the mix design procedure developed by utilizing up to 30% of the marble powder waste mixed with OPC cement by weight, to construct cool and reflective pavement was found to exhibit higher sun's reflection factor, which results in lowering surface temperature. The aftereffects of this investigation demonstrate that the utilization of marble waste can have a huge effect on bringing down the surface and air temperature. We discussed here a method that is used successfully in measuring light-reflective properties of

cement consisting of marble wastes on the laboratory. We also discussed an example in which the luminosity of contrast makes a difference. Therefore, Cool & Reflective Pavement can definitely be a boon for the road users.

REFERENCES

[1] Pomerantz, M. and Akbari, H., 1998, July. "Cooler paving materials for heat island mitigation". In Proceedings of the 1998 ACEEE summer study on energy efficiency in buildings (Vol. 9, p. 135).

[2] Synnefa, A., Santamouris, M. and Livada, I., 2006. "A study of the thermal performance of reflective coatings for the urban environment". Solar Energy, 80(8), pp.968-981.

[3] Uemoto, K.L., Sato, N.M. and John, V.M., 2010. "Estimating thermal performance of Cool & Reflective coloured paints". Energy and Buildings, 42(1), pp.17-22.

[4] O'Malley, C., Piroozfar, P., Farr, E.R. and Pomponi, F., 2015. "Urban Heat Island (UHI) mitigating strategies: A case-based comparative analysis". Sustainable Cities and Society, 19, pp.222-235.

[5] Aruntaş, H.Y., Gürü, M., Dayı, M. & Tekin, I., 2010. "Utilization of waste marble powder as an additive in cement production." *Materials & Design*, *31*(8), pp.40394042.

[6] Demirel, B., 2010. "The effect of the using waste marble powder as fine sand on the mechanical properties of the concrete." *International journal of physical sciences*, *5*(9), pp.13721380.

[7] Vartika Tripathi "Cool Pavements to Fight Urban Heat Islands" IOSR Journal of Engineering (IOSRJEN), vol. 08, no. 7, 2018, pp. 33-35.