UTILIZATION OF WASTE MATERIAL IN CONSTRUCTION OF COOL PAVEMENTS

A

THESIS

Submitted in partial fulfilment of the requirements for the award of the degree

of

MASTER OF TECHNOLOGY

IN

CIVIL ENGINEERING

With specialization in

CONSTRUCTION MANAGEMENT

Under the supervision

of

Dr Amardeep Boora
(Assistant Professor)

by

Mohit Thakur
(172602)

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT, SOLAN – 173234

HIMACHAL PRADESH, INDIA

MAY - 2019

STUDENT'S DECLARATION

I hereby declare that the work presented in the project report entitled **"UTILIZATION OF WASTE MATERIALS IN CONSTRUCTION OF COOL PAVEMENTS"** submitted for partial fulfilment of the requirements for the degree of Master of Technology in Civil Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of my work carried out under the supervision of **Dr Amardeep Boora** (Assistant Professor). This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report.

Signature of Student
MOHIT THAKUR
Roll Number – 172602
Department of Civil Engineering
Jaypee University of Information Technology, Waknaghat, Solan
____ May, 2019

CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"USE OF WASTE MATERIALS AS A COOLING AGENT IN PAVEMENTS"** in partial fulfilment of the requirements for the award of the degree of Master of Technology in Civil Engineering submitted to the Department of Civil Engineering, **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Mohit Thakur (172602)** during a period from July, 2018 to May, 2019 under the supervision of **Dr. Amardeep Boora,** Assistant Professor in Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

Date: ……

Signature of Supervisor	Signature of HOD	External Examiner
Dr Amardeep Boora	Dr Ashok Kumar Gupta	
Assistant Professor	Professor & Head	
Department of Civil Engineering	Department of Civil Engineering	
JUIT, Waknaghat	JUIT, Waknaghat	

ACKNOWLEDGEMENT

I take this opportunity to acknowledge all who has been great sense of support & inspiration throughout the project work. There are lots of people who inspired me & helped, worked for me in every possible way to provide the detail about various related topics, thus, making of report work success. My first gratitude goes to our head of department **Dr Ashok Kumar Gupta** for his guidance, encouragement & support.

I am very grateful to **Dr. Amardeep Boora (**Assistant Professor), for all his diligence, guidance, & encouragement & helped throughout the project work. I also thank him for the time that he spared for me, from his extreme busy schedule. His insight & creative ideas are always the inspiration for me during the dissertation work.

Mohit Thakur
(172602)

ABSTRACT

Fast & improper development in urban areas is remarkably expanding because of the aspects to accomplish social requirements. Without recognizing, this method comprises the mitigation of energy equilibrium of the Earth. Therefore, improper development or development without planning will create many problems which are going to affect the health, quality & luxury of adjacent communities. The everyday intimation of such ecological issues is the Urban-Heat-Island event. Building structures & pavements in urban areas are made up of low reflective power materials which ultimately can captivate great amount of heat from solar radiations & then deliver it back to the surroundings at nighttime. There are several studies that have been conceded out to look for a new expertise that can help in lessening the urban-heat-island effect (UHI). Reduction in urban-heat-island effect can be attained by (1) growing perviousness to actuate cooling effect through evaporation; (2) reducing uproar heat by composite structure; (3) cumulating the surface reflection-factor of roadway to decrease heat tapping & amassing. Due to the effect of heat island in accumulation to the universal climatic variation, rises the urban temperature & hence increases the temperature of heat waves. Thus the construction materials plays very important role at balancing & maintaining the urban environment. In this particular study, usage of waste marble powder as a partial constituent in construction of cool rigid pavement affected the surface & inner pavement temperature by 8.38 % & 5.04 % if considered percentage reduction. The average reduction in surface temperature is 2.93^0C & the average reduction in inner pavement temperature is 1.6^oC.

Keywords: Rigid Pavements, Marble Powder, Bright Colored Aggregates, Cool Pavements.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

1.1 General

In the midyear summer the urban regions encounters higher surrounding temperature during an afternoon & evening contrasted to city-side zones. To make up for such elevated temperature individuals use cooling units which expends enormous measures of power or electricity. So as to achieve the extended electric supplies civil power plants should produce out surplus power, consuming progressively non-renewable energy source, & releases extra carbon dioxide. Solitary factor behind this rising temperature in metro districts is the composite of the paved areas. Land-cover that has trees is currently claimed by people & secured by the foundations. Structures are comprised of dark materials which assimilates the sun's heat energy. Blacktop asphalt covers our lanes & tar layers the rooftops. Amid hot time such paved areas contributes to higher encompassing temperature during the past afternoon & around evening time. It makes bigger demands to cooling that disturbs the energy balance & raises emanation yields via petroleum derivative based power factories. Expanding the cooling of paved zones in urban communities can fill in as of transitive-verb methods for lessening carbon dioxide outflows & moderating environmental modification. More explicitly, reconsidering ways to deal with parking areas & low traffic street design is one technique to possibly alleviate carbon discharges. Eventually, few parking areas might be above intended for the short capacity of transportation they practice. The utilization of uniquely built pavement constituents would diminish the measure of energy consumed via parking areas, footpaths, rooftops & streets.

1.2 Heat Island Effect

Heat island effect depicts the extended surrounding temperature in urban territories in the midst of more smoking months. The sun gives vitality onto the earth as electromagnetic radiation. At the point when these radiations get entrance via our atmosphere & achieves the earth's surface, matter holds the dimension of that vitality & store it as a type of heat. The essentialness (vitality) that cannot be held is reflected. Such limit of a material to reflect or hold the daylight is evaluated in a unit less parameter known as albedo.

Hypothetically, albedo might stretch out between 0 for dull indispensable absorptive planes to 1 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 zero or one has never been seen on a

characteristic thing. Crisp dark surfaced bond concrete has an albedo of 0.04 as of the dull dim gooey asphalt material utilised to tie totals **(Akbari 2000).** Albedo is a factor that in a roundabout way determined by using an apparatus known as a pyrometer. Pyrometer gauges electromagnetic radiations in entities of essentialness per square length. New concrete bond has an albedo of 0.04 importance, it holds an enormous proportion of the sun's hot radiation & stood out from the entirety it deviates. In the midst of the most blazing time of the day, about early evening, bitumen retains the sun's energy as heat energy.

In the midst of cooler occasions, for instance, the late night & night, dark top strong discharges the heat to remain in-balance with the incorporating ambient air. Such concept of offset is solid along the 0th law of thermodynamics. Meanwhile dull planes, for instance, dark top bond, are inexhaustible in urban regions, thus there is more warmth which can be-released. These forces encompassing temperature to be raised now & again in the midst of the day when sun based energy is fewer critical. This process is identified as the heat-island-effect.

Country zones have a progressively vital dimension of their surface shrouded in shrubbery & exceedingly intelligent matters. This is the reason heat-islands are fewer explained or non-existing in such places. Following a brilliant mid-summer-day, urban temperature can be up to $5^{o}C$, higher than provincial zones **(Akbari 2001)**. Rates of city surfaces secured by asphalts can-be recognized by Geography-Information-System (GIS). In a standard metro city asphalts covers 3045% of the all-out zone **(Wong 2005).** That whole can be also dismembered to choose the level of the locale verified by stopping regions through-altitudinal GIS & airborne satellite-photograph.

1.3 Cool Pavement Technology

Cool rigid paved areas are part of roadway progression which can be used to direct urban-heat-island impacts. These decline heat being unconstrained out lately in the afternoon & amid the night-time by 2 most extreme significant keys; extended-reflectivity & extended-emissivity. Few cool inflexible pavement progressions utilizes both the characteristics.

By growing the reflection-factor of traditional-pavement, lesser the sun's crucial heat can be put away provoking fewer heat being provided for advanced discharge. Convection is the real warmth trade rule that empowers essentialness (vitality) to move between a gas & strong **(Kreith 1976).** In this way, heat vitality moving from warm asphalts to encompassing air is manipulated by temperature convection & inclinations. Empowering extra convection to happen at a speedier

way would efficiently empower asphalts to accomplish offset with chiller including air-faster. Supplementary asphalt convection is conveyed by extending interaction of the blacktop with enveloping air.

It is rehearsed by constructing pavements penetrable. In such circumstances extra air communicates with the progressively vital asphalt surface & accordingly cools faster.

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

1.4 Urban Climates & Pavements

Cool pavement systems look to handle the temperature of paved surfaces (& subsequently its capacity to exchange sun energy to the ambient air) by manipulating at least some of the matter characteristics that impact the manner in which asphalts retain, store, & radiate heat. This includes:

Albedo - Albedo, or the heat reflecting, speaks to the capacity of a matter's face to bounce back shortwave radiation (noticeable light, generally); a higher albedo implies more noteworthy capacity to reflect sunlight away. Hence, more noteworthy albedo diminishes the measure of sunlight based energy consumed by a pavement & keeps it cooler, similarly that a white vehicle remains cooler in the midyear summer than a dark vehicle. Generally, albedo is corresponded with colour – lighter colours have higher albedos.

Porosity - By permitting vapours & water to go through matter itself (or be put away inside the pores of the paved surface), porous (or pervious) pavements can exploit the cooling impact of evaporation process.

Emissivity - The flow at which a matter radiates the heat far from its face is called emissivity. The objects which has higher emissivity will radiate heat at faster rate.

Connective Airflow – Both the elements that is, porosity & unpleasantness/roughness can impact how rapidly it very well may be cooled by connective wind current. For the most part, customary asphalts set aside more effort to cool than that of permeable asphalts.

Conductivity – It is the flow at what the heat is passes in the pavement all over. The pavement which would have lower conductivity would become hot on the face quickly, perhaps it won't retain as heat as the one with greater conductivity will store.

Thickness – It influences that hoe much of the heat a pavement can store. If the pavement is thinner it would heat at faster rate in summer day but will cools much faster at night.

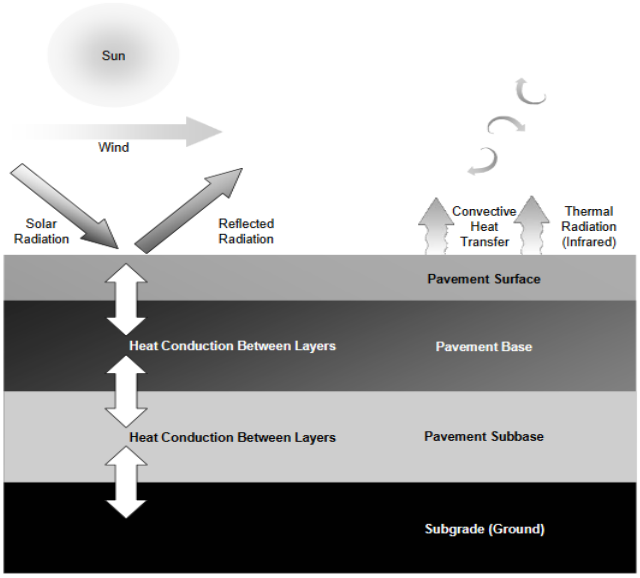

Fig. 1.1 Heat related processes & characteristics in pavements. **(Wilmers 1990)**

1.5 Waste Material Production (Marble Powder)

Concrete is one of the major construction material. Chief constituents of concrete are fine aggregate, coarse aggregate, cement & water in some required quantity. 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 the largest producer. India is estimated to have 3,127 thousands of tons of marblepowder was formed in year 200910 **(Mittal et al. 2016)**.

The waste marble powder is made 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.

CHAPTER 2

LITERATURE REVIEW

2.1 General

Most of the structures & pavements are made up of low reflective power materials which ultimately can captivate great amount of heat from solar radiations & then deliver it back to the surroundings at nighttime. There are a lot studies that have been done to look for a new technique that can help in lessening the urban-heat-island-effect. According to Syneffa et al. (2011), reduction in UHI effect can be attained by (1) growing-perviousness to actuate freezing outcome through evaporation; (2) reducing uproar by composite structure; (3) raising the surface reflection-factor of paved surface to diminish heat tapping & gathering. Prototype made up of sand, epoxy raisin & wasted tiles can enhance the surface reflection-factor of the pavement & hence can reduce the heat accumulation. In an investigational study conceded out by **Guntor et al. (2013)**, the prototype made up of wasted tiles mixed with epoxy resin when applied as a coating in a parking lot has given optimizing results for both the surface temperature & the underground soil temperature. The results for reduction of surface temperature are shown in the table 2.1 below.

Table 2.1 Temperature difference of coated-&-uncoated paved surfaces (Guntor et al. 2013)

Date	Glazed Surface Temperature (°C)	Uncoated Surface Temperature (°C)	Temperature Difference (°C)	% Reduction
Nov 9, 2011	46.2	49.9	3.7	7.41
Nov 10, 2011	45.3	48.5	3.2	6.60
Nov 11, 2011	31.8	32.7	0.9	2.75
Nov 12, 2011	39.0	41.7	2.7	6.47
Nov 13, 2011	38.7	42.1	3.4	8.08
Nov 14, 2011	47.1	51.5	4.4	8.54
Nov 15, 2011	41.3	44.2	2.9	6.56
Nov 16, 2011	48.3	52.7	4.4	8.35

According to **Santamouris et al. (2012),** Urban-heat-island is the most documented phenomenon of climatic changes & high urban temperature & this is majorly due to the greater-urban temperature when equated to the neighboring sub urban & rural areas. Thus to counterbalance the impact UHI having on urban areas, properly efficient temperature reducing techniques has been introduced & applied **(Santamouris et al. 2007)**. Use of many progressive materials for the metropolitan environment, disperse & deviate heat & sun's radiation have been

included to these techniques. Some other factors like planned remodeling of metropolises comprising suitable choice & assigning of green zones & solar control systems were also considered. Some numeric modelling has shown that the use of reflective material when applied throughout the area can lessen the ambient temperature Up to $2^{o}C$, which is a very important factor against global warming **(Santamouris et al. 2009; Synnefa et al. 2007)**. Other than these exceedingly brooding materials, the developed & progressive materials created on Nanotechnology like PCM doped surfaces or thermo chromic surfaces have been produced. The reflective materials for paving were nominated in demand to gratify some measures; a) to extant the highest imaginable durability & to aesthetically pleasing, b) to present the highest possible emissivity factor, c) to extant the lowermost likely reduction of the reflectivity since of the aged effect, d) to extant the greater probable non specular reflectivity to the lunar radiations.

Due to the effect of heat island in count to the universal climatic variation upsurges the urban temperature & hence increases the temperature of heat waves **(Santamouris et al. 2011)**. Thus the building materials plays very important role at balancing & maintaining the urban environment. Research for such materials that can be utilized in development can be grouped in four general stages. The main stage, splendid materials exhibiting exceptionally high emissivity & reflectivity have been created & talked about. Amid the second stage, cool hued materials have been created utilizing infrared intelligent shades. Third & fourth stage were stage change materials & dynamic cool materials individually. Distinctive investigations have been completed for the better comprehension of warm & optical qualities & properties of such materials just as their effect on the urban atmosphere & condition. High sun powered reflection-factor (SR) & higher infrared emittance (e) are two noteworthy properties influencing the temperature of a surface. The warm attributes of clearing materials are really noteworthy as they huge effect air temperature of lower layers of climate adding to the marvel of warmth island impact. Ordinary asphalts are commonly comprised of the material like stone, solid, blacktop, elastic, marble, rock & so forth & these asphalts can achieve the surface temperature of 4867 degree C. **Brilliant et al. (2007)** proposed to introduce photovoltaic shelters for shading asphalts in parking areas which could likewise help in delivering power. Solid asphalts can demonstrate low temperature retention if lighter shading folios, totals, sand & different materials are utilized. **Kinouchi et al. (2004)** have built up a particular sort of asphalt that fulfills low splendor & high albedo & test testing on this asphalt has demonstrated that the surface temperature of the covered asphalt is right around 15 degrees lower than the regular asphalt. Exceptionally intelligent materials

demonstrates a high cooling property amid hot days. The generation of ingredients with vibrant visual properties can be considered as a proficient answer for the issue of UHI. Be that as it may, these materials additionally indicates optical corruption & maturing issues.

Because of the urban warmth island marvel, improving the road & clearing warm condition is drawing in the expanding consideration from experts, scholastics, & contending ventures **(Xing et al. 2010).** Other than the formally recognized frameworks like reflection-factor & emissivity, permeable asphalts could be a suitable response for improving the outside warm condition & reducing the warmth island sway in hot zones.

Porous asphalts consolidate porous bitumen asphalts, penetrable inflexible asphalts, vulnerable cast unbending asphalts, & interlocking inflexible asphalts **(Hunt et al. 2008).** Vegetated permeable asphalts, for example, the greensward pavers & inflexible network pavers, utilize pliant, metallic, or solid systems for help & to enable grassland or other shrubbery to create in the openings are couple of substitutes as well. Two or three urban areas, for example, Tokyo & Osaka, have endeavored the abundance of water-retaining asphalts as a segment of utilizing porous asphalts to decrease the warmth isle impact. These asphalts can be dull top or bond built & have a sub layer that incorporates water-retaining materials that hold dampness & after that scatter it over limited development once the asphalts heat up. A touch of these frameworks consolidate underground water diverting or surface water sprinkling to improve the dissipating from the asphalts. The water to be utilized can be overseen waste water or the set away waste water.

Then again unsavoriness & void structure can develop convection & the cooling influence, they may in like way decrease the surface's net sun orchestrated reflection-factor, warm conductivity, & warmth limit **(U.S. Ordinary Protection Agency, 2008).** Such an impact may produce the open entryway that a higher surface temperature is passed on by porous dark tops. In direct daylight, dry pervious dark top become sultrier than standard dark top, showing the vulnerability of the cooling impact of the helpless dark top without spread.

As indicated by **Leadership in Energy & Environmental Design**, the solar reflective guide is the measure used in estimating the emittance & reflectivity of a material, & in this manner incorporates both sun powered reflection-factor & heat energy emittance in estimating the warmth impacts from the sun powered vitality.

Leadership in Energy & Environmental Design (LEED) affirmation framework has another definition for cool pavements; (1) Covering solid surfaces with finishing or projected

components; (2) Consuming materials with a SRI of 29 or more prominent; (3) Expending an open-matrix clearing framework that is in any event half pervious as shown in table 2.2.

Table 2.2 Albedo values for different type of pavements (Hunt et al. 2008)

Type of Pavement	Albedo Values
White Portland Cement Concrete	0.70 to 0.80 (new) 0.40 to 0.60 (old)
Bitumen	0.05 to 0.10 (new) 0.10 to 0.15 (old)
Portland Cement Concrete (Grey)	0.35 to 0.40 (new) 0.20 to 0.30 (old)

The investigation by **Syneffa et al. (2005)** represents the aftereffects of an examination that plans to explore the impact of intelligent coatings on bringing down surface temperature of structures & different exteriors of the town conditions, & in this manner test their appropriateness to bring down encompassing temperature & thus help in diminishing the heat island effect. White shading coatings performed superior to anything like, aluminium-pigmented coatings. Although every one of the coverings are described by a great sun powered reflection-factor, aluminium-pigment coverings are less desired in light of the fact that they will in general stay more hot because of their low infrared emittance.

Akbari et al. (2001) an examination about casual surfaces (cool rooftops & casual asphalts) & city trees that can majorly affect urban-heat-island effect &, thus, can diminish cooling-power use & fog/smog. The study gauged that 20.00% of the nationwide preservation request can be dodged from an extensive gage usage of the white surface. This must be assessed by the demands out on the road & about the atmosphere.

In the investigation led by **Syneffa et al. (2011)** the five shading slim layer blacktop examples that can be connected on prevailing & fresh dark pavement have been created & tried so as to assess their visual & heat execution. It was discovered that every one of the models has given higher sun oriented reflection-factor esteems & lower surface temperature contrasted with regular dark pavement. This investigation demonstrated that supplanting ordinary pavement in a street could prompt a normal air temperature up to $5^{o}C$ below short breeze speed circumstances. The aftereffects of this examination demonstrate that the utilization of shrill coating bitumen in streets & city roads can have huge effect in bringing down surface & surrounding temperature. It

is significant to make a vital arrangement to advance cool-pavements comprising estimation norms, characterized score & assessment techniques.

As indicated by the practical manual for cool rooftops & cool asphalts: Global Cool Cities Alliance (2012) a scope of ingredients are accessible for regular clearing desires. Asphalt norms can differ incredibly relying upon the utilization. Interstates, expressway shoulders, civil boulevards, parking garages, walkways, play areas, carports, connect decks, & squares all have explicit usefulness prerequisites that can be met by a scope of cool asphalt choices. Numerous sorts of penetrable asphalts, including pervious concrete, permeable blacktop, & fortified grass asphalts, are likewise viewed as cool since they can cool an asphalt surface through the vanishing of dampness put away in the asphalt. Penetrable asphalts have the additional advantage of giving tempest water the board. Some basic asphalt kinds are depicted in the counter on the confronting page.

Akbari & Matthews (2012) paper infers that expanding the sun powered reflectivity of the city surface lessens its sun powered warmth gain, brings down its temperature, & abatements its outpouring of warm radiation into the environment. This procedure of "negative radiative compelling" can help counter the impacts of an unnatural weather change. Also, cool rooftops & cool asphalts alleviate summer urban warmth islands, enhancing open air quality & solace. An ongoing report presumed that the utilization of white rooftops increments sun powered reflection-factor by around 0.40, respecting a diminished barometrical temperature equal to decreasing CO_2 outflows by 10t/100 m.

Cool-shaded rooftops that expansion sun oriented reflection-factor by around 0.21, crop a onetime CO_2 counterbalance of 5.0t/100m. The sun based reflection-factor of asphalts can be raise by & large by around 0.15. Utilizing cool rooftops & cool asphalts in urban regions, by & large, can build the mean albedo of a metropolitan zone by around 0.11. This examination gauge that expanding the albedo of metropolitan rooftops & cleared surfaces globally will actuate a undesirable radiative driving equal to counterbalancing something like 41– 161Gt of transmitted CO_2.

In research done by **Pomerantz & Akbari (1998)** they found that, in urban regions, expanding the albedo from 0.1 to 0.35, could give a cooling sparing of $0.012/m2yr. What's more, brown haze reserve funds of about $0.06/m2yr. In this manner one could buy a cooler material whose additional expense is this sum, with no net cost. On the off chance that streets are cooler they may likewise last more & in this way set aside extra cash. In this investigation an expansion in

lifetime by 30% speaks to a colossal sparing in development, upkeep, accommodation & transfer. One kind of reasonable cool surface, chip seal, is standard in the asphalt business. Notwithstanding the ecological advantages, cooler streets can be less expensive to develop, & may likewise last impressively longer than streets that are not covered with light shaded fixings.

The goal of the examination done by **Tran et al. (2009)** was to distinguish & approve high-reflectance blacktop materials that (an) are reasonable for usage in parking areas & further extensive cleared surfaces; (b) have an SRI estimation of no less than 29 (the LEED least prerequisite); & (c) are practical. In this investigation the impact of material properties on SRI is additionally talked about, i.e. for new ordinary blacktop asphalts, the SRI is for the most part low on the grounds that there is little reflectance of the dark fastener layer & little presentation of total after development.

In case light-toned is completely used operating at a profit top mix the SRI can increase over the, And acquire the surface reflection-factor record results. The freezing impact of little metropolitan green lush destinations of different symmetrical setups in summer was the target of the examination led by **Shashua-Bar & Hoffman (2000).** It was considered tentatively at 11 diverse lush locales. Two elements were found to clarify more than 71% of the mid-air temperature difference intimate the concentrated olive site, the incomplete covered territory below the tree overhang & the mid-air temperature of the non-lush settings abutting the place. Vegetation surfaces demonstrate bring down radiative temperature than other non-vegetated ones of a similar shading. The distinction in most extreme temperature may surpass 20 K.

On account of extensive green zones, for example, the parks, the vegetation influences the air temperature above it & in this way enhances the warm condition of the urban zone. The destinations contemplated here have different symmetrical designs: binary greenhouses, 4 roads, one green square, 2 yards & 2 lanes. The examination was done on estimated air temperature information at twelve assembled amid June– August 1996.

Wilmers (1990) examined that vegetation has an imperative influence with some restraint of urban atmosphere. Along these lines, Wilmers in his "idealistic meteorologically arranged city", Metutopia, saw the vegetation as the fundamental & first arranging component of the town. In

This investigation the principle parameters of the microclimatic contrasts in urban atmosphere are the article to coordinate sun oriented radiation, its span & the matter of the ground surface & the encompassing structures. Vegetation assumes a critical job by its unique appropriate ties with vitality parity & wind. Contingent upon evapotranspiration, vegetation cover & water surfaces

reduce the pinnacles of temperature amid the day. The utilization of green components together with poleoclimatotopes & choroclimatotopes nearby arranging is an essential arranging gadget to enhance urban atmosphere, particularly in the mild atmospheres yet in addition in hot atmospheres.

Doulos et al. (2004) attempted to explore the effect of the materials' optical & warm qualities on the urban temperature & in addition the conceivable vitality preservation amid the midyear time frame. The materials mulled over were marble, rock, stone, clear stone & mosaic. The surface temperature estimations were gone up against hourly premise from 09:00 AM to 06:00 PM. The example materials were utilized on the outside period of the asphalt & rooftops.

Amid pragmatic, the emissivity esteems for the aggregate number of the considered materials were near 0.9 that exists in the scope of 0 to 1. After the investigation of the aggregate amount of the asphalt constituents as per their surface shading substances it was discovered that the bright hued materials were serener than the rest. Not surprisingly the bright shaded materials were the frostiest, while the dark hued were the hottest.

These colours likewise existing a lengthy administration lifespan in typical conditions, are warm steady & artificially latent. Concrete centred materials existing unwanted warm properties & cool shades can enhance warm solace states of ease lodging, modern structures & ranch structures developed with fibre bond material sheets. Cool paints can likewise prompt a more extended administration life sequence for this sort of rooftop as shown in table 2.3.

Table 2.3 Various construction materials as cool paving materials (Doulos et al. 2004)

Paving Materials	Colour	Absolute maximum surface temperature (^oC)	Absolute minimum surface temperature (^oC)
Marble	Grey & White	36.6	22.0
Granite	White-Green	36.8	22.8
Pebble	White	38	23.0
Pave Stone	Black	49.2	28.2
Mosaic	White & Grey	37.7	22.2

Uemoto et al. (2010) contemplated that paints have four principle constituents: cover, solvents, added substances, & color. Shade gives shading, as well as controls sparkle, concealing force, quality, & porousness of the paint film. There are two fundamental classes of regular colours:

natural, with a somewhat restricted administration life & haziness, & inorganic, which are for the most part more sturdy & less helpless to the photochemical debasement. Inorganic colours likewise have greater strength under higher temperature & are artificially inactive to acids, soluble base, & so forth. The most essential innovation in the creation of cool shades is the definition with Composite Inanimate Colored Pigments (CICPs) or Motley Metallic Oxide (MMO) shades. These colours likewise existing along administration life in typical conditions, are warm steady & artificially latent. Concrete centred materials existing unwanted warm properties & cool paints can enhance warm solace states of ease lodging, modern structures & ranch structures developed with fibre bond material sheets. Cool paints can likewise prompt a more extended administration life phase for this sort of rooftop. Latent chilling of structures is an innovation portrayed by minimal effort & simple application.

In urban territory, green vegetation is helpful to enhance the warm condition in summer, **Saito et al. (1990).** Nonetheless, the green regions in urban areas are bit by bit diminishing attributable to populace increment & urbanization. In this way, air temperature in urban territories increase & a warmth island happens. The reason for this investigation is elucidation of the impact of a green territory on the warm condition in a metropolitan region, especially the chilling impact in midsummer. In this broadsheet, the connection among green dissemination & warm condition is explored. The field perceptions in extensive territories & in little regions were taken. There were high temperature zones in a few thickly developed areas secured with blacktop, solid, tab & slates. Amid the evening time, the mid-air temperature in suburbia is 2 °C lesser than the air temperature down-town. There is a great temperature district in the focal zone of the town which is secured with blacktop & solid that has a great warm limit.

Jauregui (1990) has considered that, the little green territories in urban communities, such as an extensive urban parks, then again extend a quantifiable & good impact beyond their points.

Small amount of a degree higher in the green zone.

This investigation by **Golden & Kaloush (2005**) comprises of mesoscale satellite remote detecting symbolism & micro-scale hand-held IR thermo-graph. Both these instruments are valuable in characterizing & revaluating asphalt surfaces temperature & their commitment to the Urban-heat-island. This examination has talked about the systems that have been now inspected the effects that asphalt have on encompassing temperature & surfaces. In mesoscale remote detecting parameters like (a) Soil & Vegetation Index; (b) Albedo; (c) Surface Temperature & (d) advantages of remote detecting were examined. Mesoscale remote detecting was done as

such as to distinguish the job of surface asphalts on the Urban-heat-island Effect. A consistent field imaging grind was directed to distinguish warming & sub-zero surface temperature conditions for the distinctive asphalt constituents.

Lawson & Senadheera (2009) considered & helped in distinguishing & keeping up arrangements with chip seals for flushed asphalts & draining asphalt. Components like totals, fasteners, condition, activity & development adds to draining & flushing of chip seals. In this audit paper, it was talked about that, making asphalts colder or applying cool asphalt systems diminishes the impact of draining & flushing of asphalts. It was additionally talked about that while making the solid blend, water blended with lime & different added substances was utilized in order to utilize it as a cool asphalt. This strategy is material in a crisis to capture seeping on a naturally put asphalt. The exploration findings recommend three promising territories for further research & execution with respect to answers for draining & flushing. They are the utilization of lime water, water-cutting, & covered-in seal.

Well ordered, the proportion of the marble powder (MP) as a leftover material is basically of extending in Turkey. Along these lines, the use of the excessive LP in self-packing concrete (SPC), as packing material, is the guideline focus of this examination **Topcu et al. (2009).** Additionally, the MD is used really without trying any additional strategy. Henceforth, this would be another favoured point of view for this objective. Thus, MD has superseded folio of

Just more than 200 kg/m3 content.

Due to rapid urbanization the high temperature has led to problem of UHI. Single method to grip this problem is by consuming flooring materials that has high albedo & provide low surface temperature. **Benrazavi et al. (2016)** conducted a study in Malaysia. The study had three phases: First, exploring theories regarding temperature reduction through pavement materials. Second, collecting related plans & maps for the area to conduct a field study. The last phase involved the measuring of surface temperature by FLIR E60, an infrared thermal camera imaging device. The study conducted by Benrazavi provides the reference foe taking values for surface temperature of diverse pavement materials in altered area & countryside weathers & environments.

In the examination directed by **Li (2015)** the warm execution for a few asphalt composes has been finished.

The asphalt composes significantly utilized, including solid material, square paver & blacktop material. In this investigation, two standard testing strategies for deciding sun powered reflection-factor has been made reference to: (1) ASTM C-1549 Usual Trial Process for

assurance of sun oriented reflection-factor close surrounding temperature utilizing a Moveable Lunar Reflecto-meter (2009) & (2) ASTM E-1918 Normal Trial Process for estimating sun based reflection-factor of even & little-inclined planes in ground (2005-6).

In an examination directed by **Qin (2015),** the structures at adjacent side of the road make a gulch like condition that is called road gorge or metropolitan ravine. This examination suggests a mathematical exemplary to anticipate the Urban Canyon Albedo (UCA) & approves the prototype with exploratory perceptions. The prototype thinks about the various replications among various surfaces in the metropolitan ravine. Utilizations of the prototype are loped on 2 facts: (1) if expanding the asphalt albedo successfully rises the albedo of the road gorge; & (2) if an intelligent asphalt mirrors a sizable extra diffuse radiation to adjoining structures' dividers. Parameters of the model found that the gorge perspective proportion overwhelms the UCA while different parameters assume auxiliary job. Exiling the albedo of the asphalt might successfully rise the UCA.

The fundamental target of the exploration by **Aliabdo et al. (2014)** is to research the likelihood of using unused marble powder in the link & solid creation. The examination effort was isolated hooked on two segments. The principal segment manages the properties of bond adjusted with marble powder (marble powder mixed concrete), while the second area talks about the properties of cement enclosed marble powder as a concrete replacement & as a grit replacement (bond expansion). The replacement magnitudes which had been examined were 0.00%, 4.99%, 7.49%, 10.01% & 14.85% by the mass. Water to powder percentage (w/p) or water to concrete percentage (w/c) were 0.45 & 0.35 & if there must be an existence of bond replacement & in the occasion of silt replacement independently. Physical, mechanical & substance possessions of bond & cement adjusted with marble-powder were researched. What's more, TGA, XRD & SEM investigation were made. Test aftereffects of bond glue & concrete mortar demonstrate that the marble-powder mixed bond stays inside the worthy scopes of the Egyptian norms.

Additionally, for the most part, the utilization of marble powder in solid creation as bond substitution or as sand substitution (concrete option) progressively upgrades together of the motorised & physical possessions of cement particularly with lesser w/c proportion. Marble-powder established a plaster influence in cement & had no recognizable job in the hydration procedure. However, concrete prepared with marble-powder as silt substitution accomplished restored execution contrasted with cement made with marble powder as bond substitution.

Taleghani et al. (2014) has quickly considered the impact of shrubbery & water in midsummer & all the extra vitally in wintertime. The late spring examination demonstrates that a green territory takes a 4.7oC inferior airborne temperature toward the evening in correlation with an exposed zone. The midwinter think about demonstrates that an air temperature over an olive rooftop is greater than over a grey rock rooftop. Both the late spring & winter ponders demonstrate that greens in urban communities have an inferior & extra steady air temperature Contrasted with rural areas, both in summer & winter. This paper recommends that the urban communities & their open spaces can possibly moderate urban warmth island by including additional shrubbery & marine figures. The two examinations in midsummer & wintertime demonstrated that spots by plants take a new steady mid-air temperature amid multi day in correlation with rural areas.

The temperature in a recreation centre in the downtown area was for the most part lower than the temperature in uncovered rural areas.

Vegetation assumes a critical job by its unique appropriate ties with vitality parity & wind. Contingent upon evapotranspiration, vegetation cover & water surfaces reduce the pinnacles of temperature amid the day. The utilization of green components together with poleoclimatotopes & choroclimatotopes nearby arranging is an essential arranging gadget to enhance urban atmosphere, particularly in the mild atmospheres yet in addition in hot atmospheres

Amid pragmatic, the emissivity esteems for the aggregate number of the considered materials were near 0.9 that exists in the scope of 0 to 1.

After the investigation of the aggregate amount of the asphalt constituents as per their surface shading material it was discovered that the nimble hued materials were serener than the rest. Not surprisingly the brighter shaded materials were the coolest, though the dark hued were the hottest.

In this exploratory examination by **Demirel (2010)**, the things of spending leftover marble-powder (LLP) as a fine substance on the automated assets of the strong have been inquired about. Thus, a four unmistakable course of action of strong mixes were set up by replacing the fine sand

Compressive quality. Marble powder is a symptom of marble age workplaces & moreover makes generous scale common defilement. Along these lines, it could be possible to foresee the biological sullying especially in the territories with over the top marble creation & to eat up less

normal resources additionally through its use in conventional quality concretes as a substitute for the fine aggregate.

The examination by **Wang et al. (2016)** reviews contrasting UHI helping systems in various urban neighbours of Toronto, picked by their structure thickness. The impacts of cool surfaces, that is, on the rooftops, in the city dark tops or as shrubbery districts are overviewed finished mathematical re-foundations utilizing the thing ENVI-met. Results comparably displayed that by expanding the albedo of firms by 0.2, after reasonable-lessen to average-bright shading, the refrigeration-vitality use can be diminished by around 30 to 40%. In other examination by **Taleghani et al. (2014)** displayed that in the delicate atmosphere of Portland greying solid which has albedo over 0.9, broadened the sphere & unkind amazing temperature And made a chiller mid-air temperature In examination with a dull dark top. The outcomes from the examination demonstrates that utilizing cool black top with advanced apparent albedo starting 0.2 to 0.4 & chop down warmth limit after 0.62 to 0.49 J/K, the pounded external temperature Could be decreased greatly 7.9^{o}C in the early night by 12:00pm.

In exploratory examination by **Aruntas et al. (2010**), the comfort of surplus marble-powder as an extra substance material in mixed bond has been investigated. Squander marble powder included bonds have been gotten by intergrading waste marble powder, with the Portland strong & clinker substance material in bond making.

This investigation by **Salata et al. (2017)** needed to analyse diverse alleviation procedures of the urban microclimate by mulling over the grounds of the Sapienza College in Rome. It stood helped out over the product ENVI-met V 3.1. The circumstance of urban warmth deteriorated with the urban development which now & then happened without an appropriate arranging as far as morphology & materials. Amid the stake conflict period, an expansion in the quantity of construction buildings with a subsequent difference in the scene, a few materials turned out to be more typical, as blacktop & solid, in this way deciding a Urban-heat-island (UHI) which could reason an expansion noticeable all around temperature of 3.6°C to 5°C in the covering coating. This examination analysed the exhibitions of various relief systems which were, cool rooftops, cool asphalt, more urban vegetation & a mix of each of the three arrangements, doing a correlation with the present setup of the site. The most profitable arrangement is unique with the usage of the calm rooftops, equable asphalt & extra town shrubbery.

The investigation by **O'Malley et al. (2015)** embarks to set up UHI alleviation procedures, their viability & strength to help give proposals to use of such methodologies in future. Many have

recommended that urbanization has restricted to no impact concerning environmental alteration **(Parker, 2004; Peterson, 2003),** certain others show that urban areas are adequately fit for reacting to it. This examination means to explore relief techniques. The current writing was basically inspected with a mean to examine the idea of UHI all in all & all the more particularly in relationship with the idea of manageability & flexibility at city scale for Urban-heat-island (UHI) wonder to check strength & advance urban maintainability.

Loads of marble-powder (MP) are produced in masonry industrial facilities & fair deserted as discarded affecting ecological issues **Li et al. (2018)**. A few specialists proposed to utilize the MD as bond substitution or total substitution in mortar or cement yet the advantages in concrete substance decrease & execution upgrade are very constrained. As of late, the creators have built up another strategy for utilizing inactive waste or fillers as glue substitution for more prominent advantages.

By this methodology, the leftover or grout is further to swap an identical capacity of cementitious glue deprived altering its mixture degrees. In this examination, the makers associated this technique to the practice of marble-powder in mix. A movement of grout mixtures by changing LP volume & H_2O/solid extents were complete for littler than ordinary hang shaft test, carbonation exam, & aquatic preoccupation trial & aeration decrease test. The exam marks exposed that including LP as glue substitution might liberally recover the carbonation & aquatic assurances, diminish the reduction tension & speed, & meanwhile, decline the solid substance by up to 32%.

2.2 Research Gaps

- Further research must focus on refinements of promising materials that can enhance the capability for pavement temperature reduction.
- Hierarchical research should concentrate on approaches to build consciousness of cool asphalts & advance their utilization in broad daylight & private-segment organizations, including preparing programs.
- No waste material has been utilized at that extent for the reduction of urban-heat-island effect, thus, figuring out various wastes with high albedo & mixing them with pave materials must be done.

2.3 Research Objectives

- To utilize waste material so as to decrease the temperature of rigid roadway.
- To compare the percentage reduction in temperature of cool rigid pavement to that of the conventional rigid pavement.
- To study potential cool rigid pavement methods that can be used to decrease the temperature of pavement.

CHAPTETR 03

METHODOLOGY

The project has started with reading some journals & deciding the topic. After deciding the topic we did the problem identification by reading several related research papers & review studies. After identifying what should be done, collection of materials has started. After collecting all the materials we need to perform all the related testing. The testing done should be appropriate & must follow proper & accurate procedures.

3.1 Methodology Flow Chart

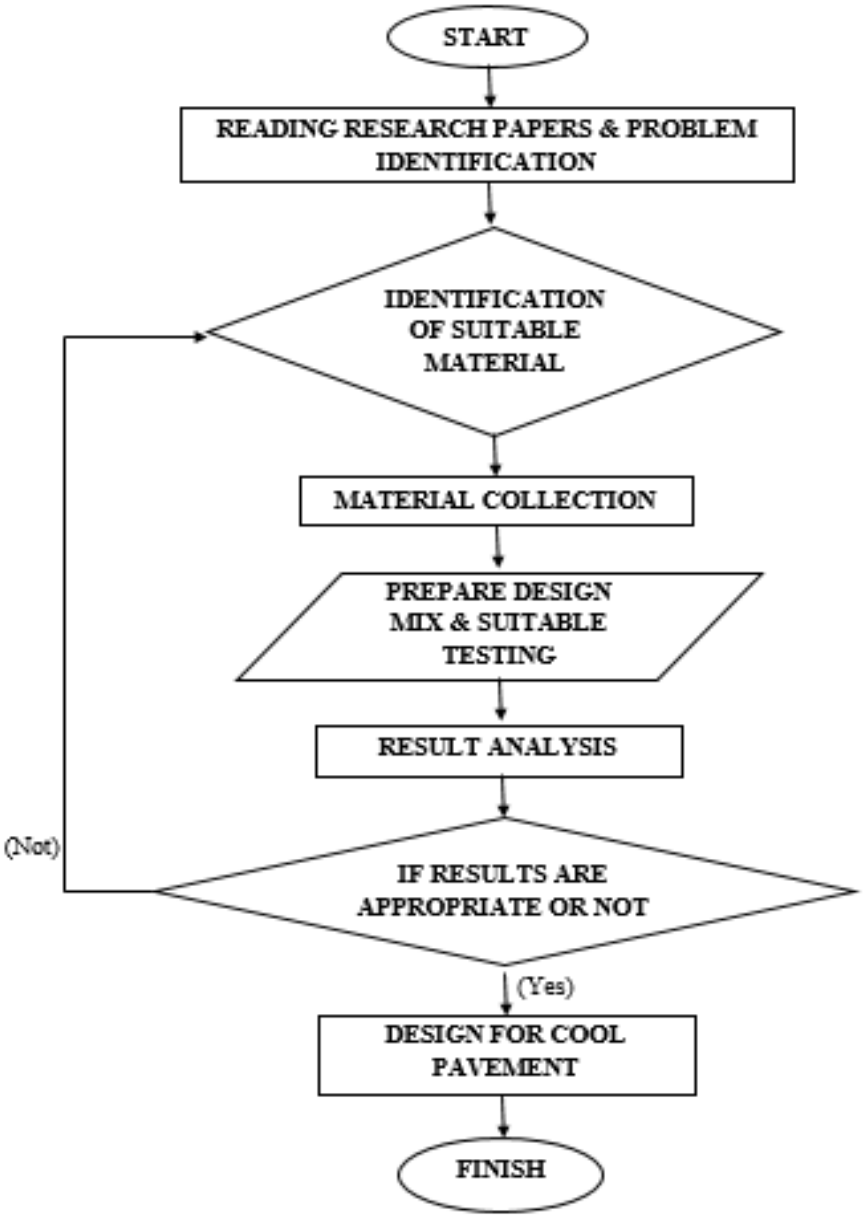

Fig. 3.1 Methodology Flow Chart.

3.2 Materials

Different waste materials were identified based on the literature reviews. Among those the following materials were found to be more suitable for the present study which are as follows:

1. Bright Colored Coarse Aggregates
2. Marble Powder (Bright Color)
3. Fine Aggregates

Besides all these materials, OPC43 is used in this study.

3.3 Experiment Parameters

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

Materials/Tests IS Codes:

1. Ordinary Portland Cement – IS8112: 1989
2. Test for aggregate – IS2386(Part 1,2,3,4,5,6,7): 1963
3. Compression test – IS14858: 2000
4. Slump test – IS7320: 1974
5. Vicat's Gear – IS5514: 1996
6. Le-Chatelier Device – IS5514: 1996
7. Basic considerations – IS456: 2007

3.4 Tests on Materials

1. Normal Consistency Test

The consistency of bond test pursues the IS 4031 (4) – 1988. The test for deciding the consistency of cement was performed utilizing Vicat's mechanical assembly & consistency plunger. The water cement proportion was taken 25%. The measuring time ought not to be over 5 minutes & ought not to be less than 3 minutes. The entrance esteem should lie between 7 to 5 mm & 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 27%.

2. Specific Gravity of Cement

Bottle Weight (W_1) = 27gm

Bottle + Water Weight (W_2) = 77.8gm

Bottle + Oil Weight (W_3) = 67gm

Bottle + Oil + Cement Weight (W_4) = 74.5gm

Weight of cement (W_5) = 10gm

Specific.Gr. of.cement

$(W_5/W_5+W_3W_3)$ X (W_3W_3/W_2W_1) = 3.12

3. Specific Gravity of Coarse Aggregate

The test for determining the specific gravity of coarse aggregate follows IS 2386 (3) – 1963. Using the wire bucket, the specific gravity test for rough aggregate was performed.

Saturated aggregates in water with basket (W_1) =1.695kg

Basket left in water :(W_2) = 0.495kg

Saturated aggregate in water Ws = (W_1W_2) = 1.2kg

Soaked surface arid aggregate in air (W_3) = 2.075kg

Oven arid aggregate in air (W_4) = 1.92kg

Water equal volume of the aggregates (W_3Ws) = .875kg

Specific.gravity of aggregate = (W_4/(W_4Ws)) = 1.92/.72 = 2.67

4. Initial & Final Setting Time

The final & initial setting.time test for cement follows IS:4031(5) - 1988. The test for determining the initial & final setting time of cement was performed using Vicat's.apparatus & setting time needles. The water must be added "0.85P" by mass of cement, where "P" is the usual constancy of cement. The first setting time of cement was measured using 1mm penetration needle failed to penetrate at 5 7 mm from bottommost of the cast &, the final.setting.time of cement is the while at which 1mm penetration needle leaves its impressions over the mould 5 mm assembly unsuccessful to create any imprint on the cast.

3.5 Preparing Concrete Mix Design

For constructing rigid pavement the concrete design of M40 is to be prepared. The mix design is prepared as per IS10262:2009. Mix proportion was done by keeping the ratio (i.e. for the weight of the different samples) as 1:1.83:2.65 while the quantity of the different materials which were used in mix proportioning is shown in Table 3.1.

Table 3.1 Stipulations for proportioning.

1	Cement Type	OPC 43 grade
2	Supreme Size of Aggregate	20 mm
3	Content of Cement	360 kg/m^3
4	Marble Powder Content	90 kg/m^3
5	Type of Aggregate	Crushed Angular
6	Exposure Condition	Normal

The materials that have been used in making M40 concrete mix were ought to be performed some basic tests in laboratory. The readings of the experiments conducted are specified in the table below.

Table 3.2 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	232-405 kg/m^3
4	Marble Dust Content	77-135 kg/m^3
5	Type of Aggregate	Crushed Angular
6	Exposure Condition	Normal

According to IS:10262 - 2009, the values for the target mean strength & characteristic strength (after 4 weeks) should be 48.25 MPa & 30 MPa respectively, as revealed in the table beneath.

Table 3.3 Mix Proportioning for Target Strength.

1	Mean Target Strength	48.25 N/mm^2
2	Characteristic Strength after 4 weeks	30 N/mm^2

For making 1m^3 M40 mix the proportions that has been taken are mentioned in the table 3.4 below.

Table 3.4 Mix proportions for 1m^3 of concrete (IS:10262 - 2009)

1	Mass of Cement	285 kg/m^3
2	Mass of Marble Dust	95 kg/m^3
3	Mass of Water	160 kg/m^3
4	Mass of Sand	711 kg/m^3
5	Mass of Coarse Aggregate	1283 kg/m^3
6	Water Cement Ratio	0.42

3.6 Chemical constituents of Marble Powder & Cement

In table 3.5, the content of Calcium Oxide (CaO) is 55.09% for the marble is in the range with the standards as cement that is 3157%. But talking about other elements like Silicon Dioxide (SiO_2), Magnesium Oxide (MgO), Iron Oxide (Fe_2O_3), Aluminium Dioxide (Al_2O_3) do not get along the standards of cement. Hence, marblepowder is somewhat characterised as cement but not completely functioning as cement. The composition is shown in the table 3.5 below.

Table 3.5 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	-

Fig. 3.2 Marble Powder used in study.

CHAPTER 4

RESULT & DISCUSSION

4.1 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 IS codes. Indian Standard code that has been used for the testing of OPC is IS: 8112 - 1989. Results of the entire basic test for cement are tabulated in Table 4.1 below.

Table 4.1 Various test results performed on OPC.

Sr. No.	Name of experiment	Results
1	Fineness	98%
2	Specific Gravity	3.12
3	Initial Setting Time	140 minutes
4	Consistency	27%
5	Final Setting Time	500 minutes
6	Compressive Strength	16.54 MPa, 26.99 MPa

Fig. 4.1 Mixing Marble Powder, Cement & Sand.

4.2 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 IS codes. Indian Standard code that

has been used for the testing of conventional coarse aggregates is IS2386 (Part 1, 2, 3, 4, 5, 6, 7): 1963.

Table 4.2 Various test results performed on conventional coarse aggregate.

Sr. No.	Name of experiment	Results
1	Crushing Test	31.6%
2	Toughness Test (Impact Value)	13.55%
3	Flakiness & Elongation Indices	1.91% & 1.18%
4	Abrasion Test (Hardness)	32.1%
5	Specific Gravity & Water Absorption Test	2.67 & 0.97%

4.3 Coarse Aggregate Testing (White Colored)

Several tests on brighter coarse aggregates (1020mm) have been conducted in the laboratories so as to achieve or check the values as per the IS codes. Indian Standard code that has been used for the testing of white coarse aggregates is IS2386 (Part 1, 2, 3, 4, 5, 6, 7): 1963.

Table 4.3 Various test results performed on white colored coarse aggregate.

Sr. No.	Name of experiment	Results
1	Crushing Test	30.99%
2	Toughness Test (Impact Value)	13.12%
3	Flakiness & Elongation Indices	1.88% & 1.14%
4	Abrasion Test (Hardness)	31.7%
5	Specific Gravity & Water Absorption Test	2.59 & 0.95%

Fig. 4.2 White Aggregates

4.4 Cement – Marble Powder (mix) Testing

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

Table 4.4 Compressive strength of cement-marble powder mix.

Sr. No.	%age of Marble-Powder	Weight of Marble-Powder	Weight of Cement	Compressive Strength (after 3 days)	Compressive-Strength (after 7 days)
1	15%	27.75gm	157.25gm	16.82 MPa	27.5 MPa
2	20%	37gm	148gm	16.96 MPa	27.7 MPa
3	25%	46.25gm	138.75gm	17.16 MPa	28.01 MPa
4	30%	55.5gm	129.5gm	16.30 MPa	27.57 MPa
5	35%	64.75gm	120.25gm	16.09 MPa	27.52 MPa

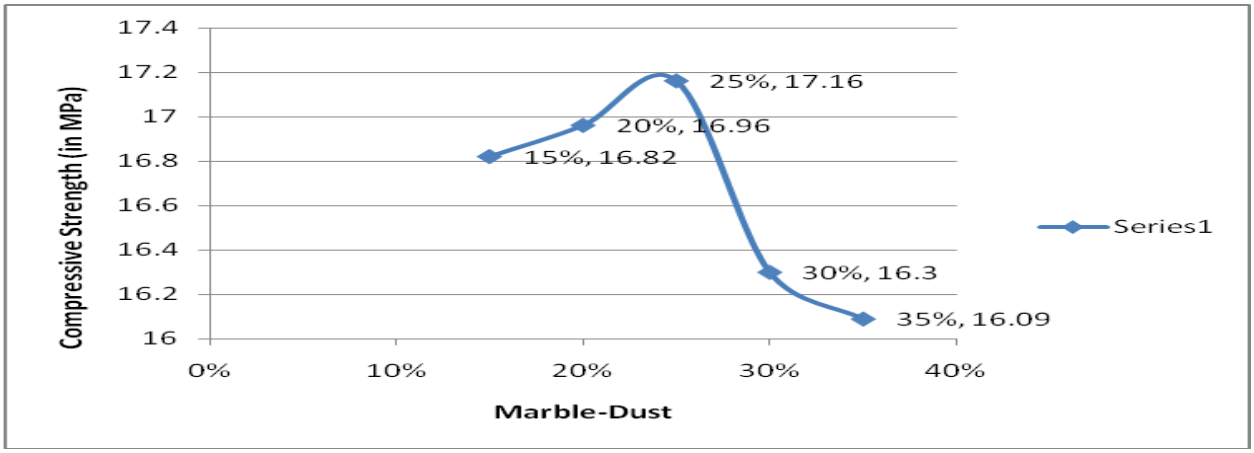

Fig. 4.3 Variation in compressive strength (3 Days) with variation in amount of marble powder.

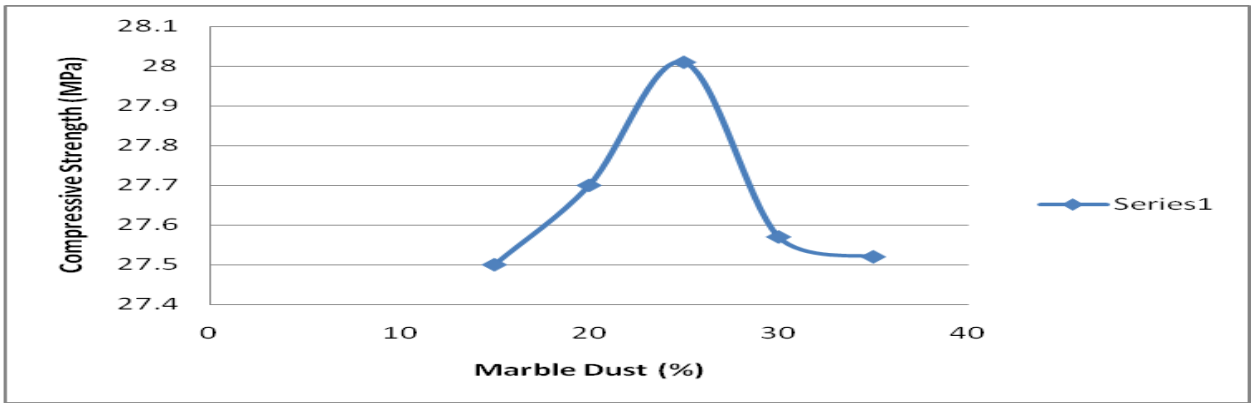

Fig. 4.4 Variation in compressive strength (7 Days) with variation in amount of marble powder.

After taking into consideration the values from upper table, it concludes that when we mix 25% of marble powder (46.25gm) with cement, we achieved the highest values for compressive

strength afterward 3 & 7 days respectively. The value of compressive strengths rises with rise in marblepowder amount up to 25%, but it starts decreasing afterwards.

Fig. 4.5 Casting mortar cubes for testing.

4.5 Mix Design Testing

The M40 concrete mix prepared with addition of marble powder gives acceptable results as per the values from IS: 10262 - 2009. The value for 28 days of compressive strength is 38.8 MPa as shown in table 4.5 below.

Table 4.5 Compressive-Strength test outcomes on Mix Design

Mix	Aggregate Size (mm)	W/C Ratio	%age of Marble Powder	Cement (kg/m^3)	MarbleDust (kg/m^3)	Water (kg/m^3)	Aggregate (kg/m^3)	Sand (kg/m^3)	Compressive Strength (MPa) (7 days & 28 days)
M40	1020	0.37	25	336	84	151	1111	768	24 & 38.8

Table 4.6 Flexural Strength test results on Mix Design

Mix	Aggregate Size (mm)	W/C Ratio	%age of Marble Powder	Cement (kg/m^3)	Fine Marble Powder	Water (kg/m^3)	Aggregate (kg/m^3)	Sand (kg/m^3)	Flexural Strength (N/mm^2) (7 days & 28 days)
M40	1020	0.37	25	336	84	151	1111	768	2.70 & 3.99

The M40 concrete mix prepared with addition of marble powder gives acceptable results, the value for flexural strength after 28 days is 3.99 N/mm^2 as shown in table 4.6.

4.6 Temperature Difference Readings

The temperature difference readings are taken for two conditions; (1) surface temperature readings & (2) inner pavement temperature readings as shown in table 4.7 below.

Table 4.7 Surface temperature reading for Conventional & Cool Pavement (at 12:00 PM)

Date	Cool Pavement Temperature (°C)	Conventional Pavement Temperature (°C)	Temperature Difference (°C)	% Reduction
Apr 26, 2019	26.5	30.6	4.1	13.3
Apr 27, 2019	30.1	32.1	2.0	6.23
Apr 28, 2019	33.6	35.9	2.3	6.40
Apr 29, 2019	35.1	39.4	4.3	11.97
Apr 30, 2019	35.0	38.2	3.2	8.37
May 01, 2019	33.5	34.9	1.4	4.01

Fig. 4.6 Thermocouple for reading inner pavement temperature

Table 4.8 Inner surface temperature reading for Conventional & Cool Pavement (at 12:00 PM)

Date	Temperature (^{0}C)		Temperature Difference (^{0}C)	Reduction (%)
	Cool Pavement	Conventional Pavement		
Apr 26, 2019	25.0*	26.3*	1.3*	4.94*
Apr 27, 2019	28.6	30.5	1.9	6.22
Apr 28, 2019	31.1	32.2	1.1	3.41
Apr 29, 2019	32.1	33.6	1.5	4.46
Apr 30, 2019	33.2	34.9	1.7	4.87
May 01, 2019	31.1	33.2	2.1	6.32

* Readings taken on the rainy day

Fig. 4.7 Thermocouple used for measuring inner pavement temperature

From table 4.7 & table 4.8 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 paved surface, hence it reflects more sunlight as compared to that of the conventional pavement. The average percentage reduction of surface temperature is 8.38 %. On the other hand, the difference in the inner surface pavement temperatures of conventional & the cool pavement was found to be 5.04 %.

CHAPTER 05

DISCUSSION & CONCLUSION

5.1 General

The urban-heat-island & how it is being caused has been discussed in first chapter of this study. Along with the heat island effect & its shortcomings, the techniques that can be used to mitigate UHI effect were also discussed. After that, selecting marble-powder as a waste material to be added in building of cool pavement was considered. Several tests were conducted to justify the mix of cement & marble powder. Using this technique for construction of cool pavement has provided appropriate results in terms of the temperature difference of cool & conventional pavement.

5.2 Discussion

The several tests were conducted for compressive as well as flexural strength of concrete mixed with marble-powder. The results achieved were acceptable & shows that the usage of granite powder as a fractional addition of concrete can work pretty well in terms of its strength. On the other hand, differences in the temperature results were found within the limit. The differences in the surface temperatures of cool & conventional pavement were found to be more i.e. 8.38%, than that of the inner pavement temperature i.e. 5.04%. The main reason of such temperature difference is due to the utilisation of waste material which provides an extra surface reflection-factor on the surface than that in inner layers.

5.3 Conclusion

In the present study, mix design procedure is proposed by utilising marble in powder form as the replacement of cement in order to execute the excess heat from the inner & outer surface of the pavement. It was observed that the mix design procedure developed by utilizing 25% of the marble in powder form mixed with cement by weight, to construct the cool pavement was found to exhibit higher sun powered reflection-factor which results in the lower surface temperature. The outcomes demonstrated that supplanting ordinary unbending pavements could prompt a normal temperature decline of 2.93^0C under summer climatic conditions. The aftereffects of this investigation demonstrate that the utilization of cool asphalt systems can have huge effect in bringing down surface & air temperature, alleviating along these lines the heat island impact &

its results. Nearby government organizations come up short on the data & motivating forces to advance the development of cool asphalts in a planned & steady route all through the city territories. It is extremely imperative to make a vital arrangement to advance cool asphalts including estimation measures, characterized rating & assessment strategies just as money related motivations for their ordinary applications.

5.4 Future Scope

For the future scope of the study, different waste materials (beside the ones which are proposed in the present study) must be identified so as to use them as a substituent of construction materials for cool pavements. Methodology of the present study can be adopted in the field for construction of cool pavement. Though, the percent utilisation of waste materials can be increased on the basis of trial and error method (i.e. by making different combinations). Along with the waste materials, new cool paving practices like; using chip seals, resin based pavements, solar harvesting, grass paving, porous concrete pavements, etc. must be practised so as to reduce the effect of heat produced by the pavements. This study can be comprehended by consuming the waste materials to construct cool roofs of the buildings & footpaths. Apart from this, the percentage utilization of the waste material projected in this study can be amplified up to or more than 50-60% by proportioning it with cement & other concrete elements. The current evidences of the cool pavements is rather restricted, as very limited projects had been commenced and the significant advancements have been done in laboratories only. It must be broadly recognized that research on cool pavements has to evolve faster.

REFERENCES

1. IS: 2386 – 1963. “Methods of test for aggregates for concrete”. Bureau of Indian Standards, New Delhi, India.
2. Kreith, F. & Kreider, J.F., 1976. “Preliminary design & economic analysis of solar energy systems for heating & cooling of buildings”. *Energy*, *1*(1), pp.6376.
3. Saito, I., Ishihara, O. & Katayama, T., 1990. “Study of the effect of green areas on the thermal environment in an urban area”. *Energy & Buildings*, *15*(34), pp.493498.
4. Jauregui, E., 1990. “Influence of a large urban park on temperature & convective precipitation in a tropical city”. *Energy & buildings*, *15*(34), pp.457463.
5. Wilmers, F., 1990. “Effects of vegetation on urban climate & buildings”. *Energy & Buildings*, *15*(34), pp.507514.
6. Kennedy, T.W., Huber, G.A., Harrigan, E.T., Cominsky, R.J., Hughes, C.S., Von Quintus, H. & Moulthrop, J.S., 1994. “Superior performing asphalt pavements (Superpave): The product of the SHRP asphalt research program”.
7. IS: 5514 - 1996. “Specification Apparatus Used in ‘Le-Chatelier’ Test”. Bureau of Indian Standards, New Delhi, India.
8. Pomerantz, M. & 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).
9. IS: 14858 - 2000. “Requirements for compression testing machine used for testing of concrete”. Bureau of Indian Standards, New Delhi, India.
10. Shashua-Bar, L. & Hoffman, M.E., 2000. “Vegetation as a climatic component in the design of an urban street: An empirical model for predicting the cooling effect of urban green areas with trees”. *Energy & buildings*, *31*(3), pp.221235.
11. Akbari, H., Pomerantz, M. & Taha, H., 2001. “Cool surfaces & shade trees to reduce energy use & improve air quality in urban areas”. *Solar energy*, 70(3), pp.295310.
12. Doulos, L., Santamouris, M. & Livada, I., 2004. “Passive cooling of outdoor urban spaces. The role of materials”. *Solar energy*, *77*(2), pp.231249.
13. Wong, N.H. & Yu, C., 2005. Study of green areas & urban heat island in a tropical city. *Habitat international*, *29*(3), pp.547558.
14. Synnefa, A., Santamouris, M. & Livada, I., 2006. “A study of the thermal performance of reflective coatings for the urban environment”. *Solar Energy*, 80(8), pp.968981.

15. Golden, J.S. & Kaloush, K.E., 2006. “Mesoscale & microscale evaluation of surface pavement impacts on the urban heat island effects”. *The international journal of pavement engineering*, *7*(1), pp.3752.
16. IS: 456 - 2007. “Plain & reinforced concrete – code of practice”. Bureau of Indian Standards, New Delhi, India.
17. Lawson, W. & Senadheera, S., 2009. “Chip seal maintenance: solutions for bleeding & flushed pavement surfaces”. *Transportation Research Record: Journal of the Transportation Research Board*, (2108), pp.6168.
18. Tran, N., Powell, B., Marks, H., West, R. & Kvasnak, A., 2009. “Strategies for design & construction of high reflection-factor asphalt pavements”. *Transportation Research Record: Journal of the Transportation Research Board*, (2098), pp.124130.
19. Akbari, H., Menon, S. & Rosenfeld, A., 2009. “Global cooling: increasing worldwide urban albedos to offset CO_2”. *Climatic change*, *94*(34), pp.275286.
20. Topcu, I.B., Bilir, T. & Uygunoğlu, T., 2009. Effect of waste marble powder content as filler on properties of self-compacting concrete. *Construction & building Materials*, *23*(5), pp.19471953.
21. 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.
22. Uemoto, K.L., Sato, N.M. & John, V.M., 2010. “Estimating thermal performance of cool colored paints”. *Energy & Buildings*, *42*(1), pp.1722.
23. Lee, K.W., Craver, V.O., Kohm, S. & Chango, H., 2010. “Cool pavements as a sustainable approach to green streets & highways”. In *Green Streets & Highways 2010: An Interactive Conference on the State of the Art & How to Achieve Sustainable Outcomes* (pp. 235247).
24. 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.
25. Synnefa, A., Karlessi, T., Gaitani, N., Santamouris, M., Assimakopoulos, D.N. & Papakatsikas, C., 2011. “Experimental testing of cool colour thin layer asphalt & estimation of its potential to improve the urban microclimate”. *Building & Environment*, 46(1), pp.3844.

26. Santamouris, M., Synnefa, A. & Karlessi, T., 2011. “Using advanced cool materials in the urban built environment to mitigate heat islands & improve thermal comfort conditions”. *Solar Energy*, *85*(12), pp.30853102.
27. Akbari, H. & Matthews, H.D., 2012. “Global cooling updates: Reflective roofs & pavements”. *Energy & Buildings*, *55*, pp.26.
28. Santamouris, M., Gaitani, N., Spanou, A., Saliari, M., Giannopoulou, K., Vasilakopoulou, K. & Kardomateas, T., 2012. “Using cool paving materials to improve microclimate of urban areas–Design realization & results of the flisvos project”. *Building & Environment*, *53*, pp.128136.
29. Li, H., Harvey, J.T., Holland, T.J. & Kayhanian, M., 2013. “The use of reflective & permeable pavements as a potential practice for heat island mitigation & stormwater management”. *Environmental Research Letters*, *8*(1), p.015023.
30. Anak Guntor, N.A., Md Din, M.F., Ponraj, M. & Iwao, K., 2013. “Thermal performance of developed coating material as cool pavement material for tropical regions”. *Journal of Materials in Civil Engineering*, *26*(4), pp.755760.
31. IS: 8112 - 2013. “Ordinary Portland Cement, 43 Grade – Specifications”. Bureau of Indian Standards, New Delhi, India.
32. Ural, N., Karakurt, C. & Cömert, A.T., 2014. Influence of marble wastes on soil improvement & concrete production. *Journal of Material Cycles & Waste Management*, 16(3), pp.500508.
33. Taleghani, M., Tenpierik, M., van den Dobbelsteen, A. & Sailor, D.J., 2014. “Heat mitigation strategies in winter & summer: Field measurements in temperate climates”. *Building & environment*, *81*, pp.309319.
34. Aliabdo, A.A., Elmoaty, A.E.M.A. & Auda, E.M., 2014. Reuse of waste marble powder in the production of cement & concrete. *Construction & building materials*, 50, pp.2841.
35. Li, H., 2015. “A comparison of thermal performance of different pavement materials”. In *Eco-Efficient Materials for Mitigating Building Cooling Needs* (pp. 63124).
36. Qin, Y., 2015. “Urban canyon albedo & its implication on the use of reflective cool pavements”. *Energy & Buildings*, *96*, pp.8694.
37. O’Malley, C., Piroozfar, P., Farr, E.R. & Pomponi, F., 2015. “Urban heat island (UHI) mitigating strategies: A case-based comparative analysis”. *Sustainable Cities & Society*, *19*, pp.222235.

38. Benrazavi, R.S., Dola, K.B., Ujang, N. & Benrazavi, N.S., 2016. “Effect of pavement materials on surface temperature in tropical environment”. *Sustainable cities & society*, 22, pp.94103.
39. Wang, Y., Berardi, U. & Akbari, H., 2016. Comparing the effects of urban heat island mitigation strategies for Toronto, Canada. *Energy & Buildings, 114*, pp.219.
40. Salata, F., Golasi, I., Petitti, D., de Lieto Vollaro, E., Coppi, M. & de Lieto Vollaro, A., 2017. “Relating microclimate, human thermal comfort & health during heat waves: An analysis of heat island mitigation strategies through a case study in an urban outdoor environment”. *Sustainable cities & society, 30*, pp.7996.
41. Li, L.G., Huang, Z.H., Tan, Y.P., Kwan, A.K.H. & Liu, F., 2018. Use of marble powder as paste replacement for recycling waste & improving durability & dimensional stability of mortar. *Construction & Building Materials, 166*, pp.423432.