A THESIS ON

A STUDY ON INTERLOCKING CONCRETE BLOCK PAVEMENT PERFORMANCE USING MODERN CONSTRUCTION TECHNIQUES

Submitted for partial fulfilment of award of

MASTER OF TECHNOLOGY

Degree in

(CONSTRUCTION TECHNOLOGY & MANAGEMENT)

By

SHADAB AHMED

(Roll No.: 1800103998)

Under the guidance of

Mr. Zishan Raza Khan

(Associate Professor)

Department of Civil Engineering

Integral University,

Lucknow–226026,

Uttar Pradesh,

2019-2020

DECLARATION

I hereby declare that the research thesis entitled "**A STUDY ON INTERLOCKING CONCRETE BLOCK PAVEMENT PERFORMANCE USING MODERN CONSTRUCTION TECHNIQUES**" is the bonafide research work carried out by me, under the guidance of **Mr**. **Zishan Raza Khan**, **Associate Professor, Department of Civil Engineering, Integral University, Lucknow**. Further I declare that this has not previously formed the basis of award of any degree, diploma, associate-ship or other similar degrees or diploma, and has not been submitted anywhere else.

Date: SHADAB AHMED

Place: Enroll.no.1800103998

Department of Civil Engineering,

Integral university, Lucknow, U P.

CERTIFICATE

Certified that the thesis entitled "**A Study On Interlocking Concrete Block Pavement Performance Using Modern Construction Techniques**" is being submitted by **Mr. Shadab Ahmed 1800103998** in partial fulfilment of the requirement for the award of degree of Master of Technology (Construction technology and management) of Integral University, Lucknow, is a record of candidate's own work carried out by him/her under my supervision and guidance.

The results presented in this thesis have not been submitted to any other university or institute for the award of any other degree or diploma.

Mr. Zishan Raza Khan

Associate Professor

Department of Civil Engineering

Integral University,

Lucknow, U P

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Date: (SHADAB AHMED)

Place: Enroll No.1800103998

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ABSTRACT

The interlocking concrete block pavement (ICBP) has gained fast popularity in many overseas countries as an alternative to concrete and asphalt pavements. However the visible return of ICBP has not fully extended in India because of lack of own verified design and construction information. Paver blocks form a part of the segmental paving system, the methodology used in the design of interlocking concrete paver block pavements is the same as that used for the design of flexible (asphalt) pavements. The paver block surface is placed over a graded sand base and interlocking behaviour will resist between the interlocking pavers block with the help of bedding and joint sand, because bedding material with appropriate thickness provide a cushion to observed the stress developed by the pavers block during the movement of the commercial traffic, beneath the bedding sand the substructure is similar as flexible pavement. We have tried to establish a relation between the different shape of interlocking concrete paver blocks as unipaver block, round dumble block, dumble block, L shape, with respect to its different type of bedding materials as natural coarse sand, stone dust, (fly ash+ stone dust + varying proportion of poly propylene fiber (1%, 2%), with effective thickness as 25mm, 30mm, 35mm, 40mm, which are best suit for the interlocking concrete block pavement to ensure less settlement in bedding material during load test as per recommendation of the standard axle load by IRC on the respective observation values and cost analysis of the interlocking concrete block pavement with cost of different flexible pavement exist.

Keywords: Different shape of interlocking concrete block pavement, Flexible Pavement, Different types of Bedding Material, Cost Comparison analysis etc

CHAPTER 1

INTRODUCTION

1.1GENERAL

The interlocking concrete blocks pavements are also known as block pavemets.There are several laying pattern is under use which may be boardly categorize in two parts A.INTERLOCKING PATTERN .

B.NON INTERLOCKING PATTERN

A.INTERLOCKING PATTERN

Interlocking Concrete Paving Block: It is an enhanced form of conventional concrete paving block, each block is design constructively to lock other paver blocks without any use of mortar.

Figure1. Interlocking pattern

B. NONINTERLOCKING PATTERN

Non Interlocking concrete paving block: It is conventional concrete paving block which are designed without self locking behavior. Locking properties developed by the use of mortar.

Figure 2. Non Interlocking Pattern

1.1 Advantages and Limitations of Interlocking Concrete Block Pavements.

Advantages

(i) Since the blocks are prepared in the factory, they are of a very high quality, thus avoiding the difficulties encountered in quality control in the field.

(ii) Concrete block pavements restrict the speed of vehicles to about 60 km per hour, which is an advantage in city streets and intersections.

(iii) Because of the rough surface, these pavements are skid-resistant.

(iv) The block pavements are ideal for intersections where speeds have to be restricted and cornering stresses are high.

(v) The digging and reinstatement of trenches for repairs to utilities is easier in the case of block pavement.

(vi) These pavements are unaffected by the spillage of oil from vehicles, and are ideal for bus stops, bus depots and parking areas.

(vii) They are preferred in heavily loaded areas like container depots and ports as they can be very well designed to withstand the high stresses induced there.

(viii) In India, the laying of concrete block pavements can be achieved at a low cost because of the availability of cheap labour.

(ix) Since the concrete blocks are grey in colour, they reflect light better then the black bituminous pavements, thus bringing down the cost of street lighting.

(x) The cost of maintenance is much lower than a bituminous surface.

(xi) Block pavement does not need in-situ curing and so can be opened to traffic soon after completion of construction.

(xii) Construction of block pavement is simple and labour-intensive, and can be done using simple compaction equipment.

(xiii) Maintenance of block pavement is simple and easy. Also, the need for frequency of maintenance is low as compared to bituminous pavement.

(xiv) Structurally round blocks can be recycled many times over.

(xvi) Use of permeable block pavement in cities and towns can help replenish depleting underground sources of water, filter pollutants before they reach open water sources, help reduce storm water runoff and decrease the quantum of drainage structures.

Limitations

(i) Concrete block pavements cannot be used for high speed facilities.

(ii) The riding quality is reasonably good for low-speed traffic,

Figure .3 Production of icbp at factory

Figure . 4 A Stack of manufactured interlocking concrete block pavers at the factory side

1.2 BACKGROUND OF THE STUDY

The interlocking concrete block pavement are newly and integral part of the system for entire constuction world. The concrete block pavement concept was developed later to the roads of the Roman Empire, In the last 1940‘s Netherlands were developed Concrete pavers as a replacement for clay brick streets, In the 1970‘s North America was developed concrete pavers they have been successfully used in residential, commercial, municipal, port and airport applications. Rectangular paver of size 240mm x 120mm x 80mm were successfully used under heavy traffic in germany 1936. Now a days, The interlocking concrete paving blocks of size 200 mm to 250 mm in length and 100 mm to 112 mm width and the thickness of the paving blocks in ranges from 60 mm to 100 mm, depending on the requirement of traffic. The paving blocks are laid on a sand bed of 20 mm to 40 mm thick, filling by sand joints of 2 mm to 4 mm. Interlocking concrete block pavers have different shape and its linked properties together with more accurate manner in reference to previous decades design and its construction. Because fast fit together, good drainage posibilities,easily reassamble of defect area,low maintenance cost ,mass production, non high skill labour required for thier laying.In lucknow city,the vast usage of interlocking concrete block pavement was used from last few decades,at only footpath,padestrian,petrol pump,cycle track, public park and as well as local street of the city. Numbers of prior research studies were conducted on CBP had try to change the conventional rectangular concrete block shape, an introduced further side interlocking features, and design preferable interlocking shapes. CBP is utilized globally because it is durable, non-skidding and dimensionally accurate; available in many sizes; and has good structure and colour. Additionally, these CBP can be installed by unskilled labourers and can be re-used on the same site or elsewhere.

The main observational point is that the overall performance of the interlocking concrete block pavement is not reachable as per requirement due to block paver pavement damage by the various reasons such as unfavourable drainage on block pavements,unadequate thickness of bedding sand,different load carrying capacity of unit block paver,thickness of block as per traffic loading capacity, base and sub base are not designed as per requirement according to that city physical norms. Because in lucknow city most of the area is highley dense due to that the network of water system,drainage system,sewerage system etc are all comes below the finished surface of pavements.so,it is very challenging issues to spread the networks of public utility services beneath level of the pavement surface as well as considered its repairs and reconstruction of the network function. Interlocking concrete pavers block are use for municipal application is better and it adopted by the entire world. Mostly during construction of icbp pavements, the bedding course sand is also used in joint filling instead of joint sand.

Interlocking block paver block a new alternative for construction world for fast fitting installation were made with closely constricted stone paving piece laid over a base surface. Bedding sand gives a frictional force between concrete blocks to prevent the block moving towards.   Post the world war-II, bulk production of the concrete blocks and spread widely in the construction field to used as a alternative of stone pavers or bricks pavers. The latest version, interlocking concrete paving block is manufactured with a strict variation to develop interlock by design pattern. Interlocking concrete block pavements for the Commercial stream of traffic like Arterial road and Sub Arterial road and highway sections subjected to commercial stream of traffic (trucks and buses) required adequate pavement section.

However design procedure based on mechanistic behaviour and empirical approach can be considered, but enough work has not been done in India to develop the country's own design procedure. Lack of such expertise, the impromptu design catalogues based on world wide experience are suggested for adoption (as per IRC:SP:63-2004). To resolve bedding sand and overall performance of interlocking concrete block pavement by various approach in previous research by the researcher in different countries.

(i) change in mix design
(ii) addition of admixtures.
(iii) thickness of bedding material
(iv) variation of thickness
(v) different size (9inch×4.5 inch ×4 inch) ,(9 inch×4 inch×3.8inch) etc.
(vi) Addition of cement/cementanious properties in different grade of concrete.

Figure .5 Settlement of bedding material due to this uneven surface appear.

Road Categories In Lucknow City Capital Of Uttar Pradesh India : The hierarchy is based on the function that the road is expected to perform, and the type of traffic and the road users present on the road. The design speeds, road widths and other geometric features are adapted to suit the road function. These guidelines are based on the following classification of urban road:

1. Arterial Roads

They are the primary roads for ensuring mobility function. They carry the largest volumes of traffic and longest trips in a city. These roads are characterized by mobility and cater to through traffic with restricted access from carriageway to the side. In such cases, special provisions should be introduced to reduce conflict with the through traffic. These roads have the maximum right of way amongst the four categories and cater to a speed limit of 50-60 km/h and a row of 50-80 m.

2. Sub Arterial Roads

This category of road follows all the functions of an Arterial Urban road and are characterized by mobility, and cater to through traffic with restricted access from carriageway to the side. It carries same traffic volumes as the arterial roads. Due to its overlapping nature, Sub arterial roads can act as arterials. This is context specific and is based on the function and the land use development it passes through and caters to a speed limit of 50 km/h (same as arterial roads). The row of this category of roads varies from 30-50 m.

3. Distributor/Collector Roads

As the name suggests, these are connector roads which distribute the traffic from access streets to arterial and sub arterial roads. They are characterized by mobility and access equally. They are characterized by a design speed of 30km/h and have a row midway of access streets and two types of arterials i.e. 12-30m. It carries moderate traffic volumes compared to the arterial roads. Due to its overlapping nature, distributor roads can act as an sub arterial and as access streets, depending upon the function and the land use of the surroundings

4. Access Streets

These are used for access functions to adjoining properties and areas. A majority of trips in urban areas usually originate or terminate on these streets. They cater to a design speed of 15-30km/h and have a road right of way of 15m-30m. They carry relatively lower volumes of traffic at low speeds. They are characterized by access predominantly; they can be used for collector functions. Based on the function the classification of the roads is decided and an appropriate design speed is adapted. The design speed governs the geometric design of the right of way and the round section elements of the road. IRC: 86–1983, Geometric Design Standards for Urban Roads in Plains, Indian Road Congress, 1983.

Bedding Materials	**Different thickness**	**Fineness Modulus**
1.Natural coarse sand	25mm to 40mm	3.07
2. Stone dust	25mm to 40mm	3.01
3.Flyash + stone dust + mix of poly propylene fiber in varying percentage	25mm to 40mm	3.2

Table 1.Types of bedding materials and their fineness modulus range

Bedding Material : It must consist of multi-sized sand particles, including concrete sand, to effectively lock the pavers into place. Maximum 40mm layer of label sand allows pavers to sink slightly into the bedding to hold them firmly in place

Fly ash or **flue ash**, also known as pulverised fuel ash in the United Kingdom, is a coal combustion product that is composed of the particulates (fine particles of burned fuel) that are driven out of coal-fired boilers together with the flue gases. Ash that falls to the bottom of the boiler's combustion chamber (commonly called a firebox) is called bottom ash. In modern coal-fired power plants, fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys. Together with bottom ash removed from the bottom of the boiler, it is known as **coal ash**.

Depending upon the source and composition of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline), aluminium oxide (Al_2O_3) and calcium oxide (CaO), the main mineral compounds in coal-bearing rock strata.

a) Admixture — A material other than water, aggregates, cementitious materials, and fiber reinforcement, used as an ingredient of a cementitious mixture to modify its freshly mixed, setting, or hardened properties and that is added to the batch before or during its mixing.

b) Bottom Ash — Pulverized fuel ash collected from the bottom of boilers by any suitable process.

c) Calcareous Pulverized Fuel Ash — Pulverized fuel ash conforming to the provisions of calcareous fly ash given in this standard and having reactive calcium oxide not less than 10 percent by mass. Such ash is normally produced from burning lignite or sub bituminous coal and has both pozzolanic and hydraulic properties.

d) Fly Ash — Pulverized fuel ash extracted from flue gases by any suitable process such as by cyclone separator or electro-static precipitator.

e) Mound Ash — Fly ash or bottom ash or both mixed in any proportion and conveyed or carried in dry form and deposited dry.

f) Pond Ash — Fly ash or bottom ash or both mixed in any proportion and conveyed in the form of water slurry and deposited in pond or lagoon.

g) Pulverized Fuel Ash — Ash generated by burning of ground or pulverized or crushed coal or lignite fired boilers. It can be fly ash, bottom ash, pond ash or mound ash.

i) Reactive Calcium Oxide (CaO) — That fraction of the calcium oxide which under normal hardening condition can form calcium silicate hydrates or calcium aluminate hydrates. NOTE — To evaluate this fraction, the total calcium oxide content is to be reduced by the fraction calculated as calcium carbonate (CaCO3), based on the measured carbon dioxide (CO2) content and the fraction calculated as calcium sulphate (CaSO4), based on the measured sulphate (SO3) content, disregarding the SO3 taken up by alkalis.

j) Siliceous Pulverized Fuel Ash — Pulverized fuel ash conforming to the provisions of siliceous fly ash given in this standard and having reactive calcium oxide less than 10 percent, by mass. Such ash is normally produced from burning anthracite bituminous coal and has pozzolanic properties.

Table 2. Physical Requirements of fly ash (Clauses 5.1 and 7.1) of IS: 3812-2003

Sl No.	**Characteristic**	**Requirements**
i)	Fineness — Specific surface in m2 /kg by Blaine's permeability method,	Min 200
ii)	Particles retained on 45 micron IS sieve (wet sieving) in percent1),	Max 50
iii)	Soundness by autoclave test — Expansion of specimen in percent,	Max 0.8

Calculate the percentage of moisture to the nearest 0.1 percent as follows:

Moisture content, percent = $\frac{x}{y} \times 100$

Where

x = loss in mass of fly ash during drying;

y = mass of fly ash taken, as received basis.

Joint Sand: Maximum particle size of 1.18 mm and less than 20 % passing the 75 µm sieve has performed well for finer jointing sand. The vast usage of interlocking concrete paver blocks is due to string way and either its design of surface on which blocks are laid.

This topic will discuss about the load carrying capacity of different shape of interlocking concrete block to accumulate the settlement of bedding surface on different bedding material thickness of interlocking concrete block pavement with cost effectiveness will also consider and enhancement over conventional techniques by using new construction techniques.

1.3 OBJECTIVES OF THE STUDY

Objectives of the study are as follows:

1. Assessment of load versus deflection behavior of different paver block and bedding material combination.

2. Cost Analysis of different combination of pavers blocks at different bedding materials.

1.4 SCOPE & LIMITATION OF THE STUDY

The scope of this work was confirmed to attain the objectives overall completed by the following study.

i) Limited to Lucknow city which is indoplainregion.

ii) Suggested specific shape and its thickness, bedding material type and bedding material thickness of interlocking concrete block pavement by the help of desired test performance to reduce initial cost of construction and maintain desirable quality with the help of modern construction techniques.

iii) Emphasis on different shape over different bedding materials combination to ensure our objectives.

Lucknow an area of study : Lucknow is capital of Uttar Pradesh and the integral part of the Indian States. It is located at an elevation of 123 meter (404ft) above mean sea level having area covered about 2528 sq.km with peripheral boundaries in east by Barabanki, in west by Unnao, in north by Sitapur-Hardoi and in south by Raebareli. Lucknow is a historical city with old and new infrastructure and monuments and also most popular as Awadh-city of nawabs.

Figure.6- Map of Lucknow City

Smart City: According to smart city , perception were made in which the smart cities project mission is to reform social and economical growth and make better planning for unplanned areas to make more efficient or developed and promoting overall services which are available in new way to make life of people as well as cultural development of an area will more convenient and easy. Lucknow Nagar Nigam were divided into six zone as Zone 1, Zone 2, Zone 3,Zone 4, Zone 5, Zone6, most of the zones considered as smart city project development by the government authorities.

Lucknow as a smart city: The art city becomes smart city, numbers of infrastructural project activities were fast growing by the mission of government of india and state government to make smart views of the city geographically demonstration for social and economics growth of the city.

In that infrastructural development interlocking concrete block pavement (icbp) are play an important role to make city roads or pavement fast fitting and neat and clean to reform unplanned areas with effective pavement construction. Because the use of icbp were permitted by the IRC:SP:63:2004 in any smart city or any development work which are needed of that types of pavement wherever. for fast fittings and better apparent.

(i) Concrete block pavements restrict the speed of vehicles to about 60 km per hour, which is an advantage in city streets and intersections.

(ii) In India, the laying of concrete block pavements can be achieved at a low cost because of the availability of cheap labour.

(iii) Use of permeable block pavement in cities and towns can help replenish depleting underground sources of water, filter pollutants before they reach open water sources, help reduce storm water runoff and decrease the quantum of drainage structures.

A View of Study Area of Lucknow City Transform Into Smart City

Figure .7 (a) Photo of imambada known as Bhoolbhulaiya

Figure 7(b) Pictures of Rumi Darwaza

Figure .7 (c) Clock tower pictures of zone 6 in smart city development

Figure .7 (d) proposed picture of Smart city

CHAPTER 2

LITERATURE REVIEW

1.**T.Muraleedharan, P.K. Nanda :** they was carried out the laboratory study to understand the engineering behaviour of icbp in this laboratory study special attention on in-house test facility in which a mark area of 18m*6m with compacted sub grade and excavation work complete for base coarse 100mm and block size 60mm ,design period 10 years ,design traffic 10 million std axles, season 1, temperature 25 degree c and applied static plate load test on it to check static soil modules (Es) and the sub grade reaction modulus (K) capacity of the surface. Dynamic plate load test (falling weight deflection) FWD were performed on entire surface to obtain subsoil deformation measurement, which gives required values which are to be used in designing purpose.

2.**Anthony N.S Beaty , et.al. :** were introduced about the studied on the specification of bedding sand. According to that studied, the cases of heavy channelized loading of structural, interlocking concrete block pavements specially in wet climates, little number of failures have been introduced to use of unsuitable bedding sand. Such failures are costly in terms of reconstruction, litigation, and damage to the image of interlocking concrete block pavement to resist traffic load and industrial load, to provide even surface on which to lay the blocks. To develop interlock-uniform thickness grading of the sand 13% to 10% of 75 micron m, Angularity of sand particles, free drainage (dry condition) tendency to accumulate the joints between blocks, to resist the mechanical degradation.

3.**Shackel Brain** : In this paper the author described over all previous research and development techniques which are carried out on concrete block paving technology that are sufficient to the usage of blocks pavements in construction engineering market. The main attention of the author on new market which are easier approach to designers,engineers as well as end users and the market of pavers block are to be highly popular with their significance and advantages.

a–Develop new design procedures to estimate the different traffic loads,environmental factor.(such as climatic factor).

b–provide sufficient knowledge for the entire design and implement section as the concrete block pavement is also a type of pavements like asphalt or rigid concrete paving.

The main consideration in design surfaces are as-

pavers –physical properties

bedding sand – M sand

joint sand – dry state

base coarse – required size compacted aggregate

4.**J.B.Metcalf , K.G.Sharp :** The research carried out by the main important issues on block shapes (rectangular v/s shaped debate). And it was accepted every shaped have its own place according tothe requirements.The main aim was to considered on the claim over advantage like–colour, where were the data,as compare to asphalt–where were the data,skid resistance - where were the data,construction tolerance –levels should be 10mm (+) or (-) not accepted due to lack of data.The two main things CACA design chart and Brithish Ports Association design chart are based on the elastic layer modelling.ELM is good way for approach the design of block pavement for australia,even surface is non homogenous because it is a techniques known and accepted by australian pavement designers.The need to monitor the design ,construction and performance of in services interlocking block pavement cannot be over emphasised.

5.**M.P.Karthik, Dr.V.Sreevidya, et.al. :** carried out the study and uses of opc grades 53 as per IS:10262,aggregate size 20mm with specific gravity is 2.9,mix proportion M20 and M40 grades.For making block rubber mould were used as the size of block were 215mm x 170mm x 55mm or 200mm x 100mm x 80mm I-Shape paver block, ground nut husk ,test as per IS 15658:200, 3cubes test ,average value is noted for reported.compared to conventional mixture.Nylon fiber- provide more frosted than other paver block and 20% of rice husk gives high best possible results with strength of paver block.Addition of coconut fiber by 0.3% paver block attains maximum compressive strength.

6.**B.SHACKEL :** In this research the author conclude over various tests for the interlocking concrete block pavement under accelerated trafficking. In this research static plate loading evaluation for small areas of about 4m^2 c of icbp in real pavement fall under the dynamic and insistent loadings put on the road traffic. Design problem can be estimated in detailed from the testing several shape and size of the blocks, and also their base, sub base, laying and strength of individual block.In present time existing scenario is sufficient for design of block pavement. An important addition to faciliate the construction techniques usable to the pavement engineer.

7.**Hasanan Md Nor, et.al. :** According to this paper emphasis on the experimental outcomes fit for cement content and water cement ratio in the producing of concrete paving block. Cement content of 12%and15% in concrete mix at several w/c ratiototal60concretemix producing and tested over physical parameter like dry density, skid resistance, and its compressive strength of the concrete paving block. Design strength level as 20Mpa to 33Mpa and 31Mpa to 42Mpa was gained from w/c ratio 0.50 to 0.70 for 12% cement content and w/c ratio 0.45 to 0.65 for 15% cement content. It shows that the block pavers having 12% cement content is feasible for producing and hence get the minimum compressive strength (30Mpa) for traffic area below 3 tonnes its gross weight. The cement concrete paving block having low w/c ratio is better skid resistance.

8.**Nur Hidayah A.H., et.al. :**In this paper the performance of interlocking block pavement by the load distribution between the blocks and the jointing sand. Because jointing sand in block joint offer frictional resistance to prevent the blocks paver from out of lines when load is imposed. Several sizes of jointing sand (2mm,5mm,7mm) with jointing width of blocks (2mm,4mm,6mm) are used for the performance of concrete block pavement.After consideration on results 2mm jointing width of blocks is more desirable to use for jointing sand of size 2mm and if jointing width of blocks is 6mm is good to use for jointing sand of size below 7mm.

9.**Gonzalo R. Rada, et.al. :** In this paper ,entire focus on research gap which are comes out from the existing several methods for designing interlocking concrete block pavements,because all researcher emphasis on subgrade soil,due to settlement of paving materials,environment,and anticipated traffic but number of limitation connected with each, as lack of pavement performance future outcomes capabilities, and assurance to specify expectation pavement failure and reliability level. The ASASHTO flexible pavement design methodology were adopted during this procedure.The several modification were made over this procedure ,the traffic doesnot above 2000,000 EALs, and block thickness is 80mm and the bedding sand is 25mm are recommended.

10.**Shackel.B :** This paper report the experimental testing of several both well established and newly produce pavers.under laboratory condition pavers were passes using special test plan to satisfy that the paver surface could be characterized independently of any bedding or pavement sub structure. In terms of resilient modulus load distribution capabilities can be explained. Factors included the shape and the lying pattern of the pavers.The test implies that the most factor impelling the load distributing features of the pavers is their shape and no more affect of lying pattern on the performance of the pavers.several level of values of resilient moduli.

11.**Purwanto, et.al. :** In this paper the outcomes is that the strength of the interlocking blocks pavers is award by the maximum carrying capaciy under distributed load. The pavings failure mode is affirm by a bendding failure plain at the smallest round section.Axial load carrying capacity

$$\sigma = \frac{P}{A}$$

T= is the paving block streng

fp= is the paving block compression strength in Mpa

fp= 14.63T^1006

T= 0.086 0.912√fp

12.**Khaled and Mehedy :** Performed laboratory test to estimate the performance of a cement stabilized pavement base course material limited of recycled concrete aggregate ,ASTM class c fly ash ,and waste plastic (high densiy polythelene) strips get from post consumer water and milk containers. it was found that the unreinforced mixture containing92% recycled concrete aggregate , 4% fly ash and only 4.5 % cemnt achieved compressive strengthof about 5 N/mm^2.

13.**Pretorious, et.al. :** This Paper is emphasis on the findings of the subsequent enginering failure study as well as the engineering solution and establish feedback to reduce future failures.The main failure reason for rapid filures is improper bedding sand thickness,improper bedding material ,improper filler sand and rough compaction of the paving blocks layer and drainage also a failure reason. For acheiving good quality superior process and quality controll and technical consideration are required for the paving surface.

14.**A.K. Pani, et.al. :** In this paper the mix design of several grade are adopted as M30 ,M35, M40 with different cement content and w/c ratio and from this compressive strength ,flexural strength for all mix at 7,14,28 days consideration. IRC:SP:63-2004 and IS 10262-2009 ,IS 15658:2006 ,IS 456:2000 are carrierd out for the entire experiment. According to IS 10262 :2009 after 28 days compressive strength shall not be less than 85% of the mix grade. For manufacturers of paving block must have follow their mix design procedure for quality products.
As per guidelines of irc:sp:632004.
MIXproportion:
1:2.72:1.8
1:2.69:1.79
1:2.91:1.94

15.**Shackel.B :** From that paper carried out some basic consideration for the new technology as four areas are as-
1-Paver manufacture, quality control and specific standards.

2-Evaluation of paving through direct testing an case histories.

3- Design of pavement.

4- Installation and maintenance of pavement.
According to this paper the following factors affecting the performance of Interlocking concrete block pavement as paver shape, thickness of block, size of block, joint width of blocks, bedding sand thickness, moisture, material type, grading, soil type, strength and durability of base coarse and sub base coarse from whole things, it is essential that paver manufacturer and suppliers need to introduced the technology of concrete block pavement in civil engineering works.

16.**Muraleedharan.T, et.al. :** In this paper CRRI gives more emphasis on the techniques which are adopted for the draft own indian standards specification for concrete paving block with some development and a application of special purposes. 1-the several shape are exist as hexagonal and pentagonal shaped, interconnected, heavy duty concrete block pavement for direct paving in desert/sandy region. 2-rectangular block create ways for small rural communities.

3-hexagonal and square concrete block for paving footpath and bus stop in urban areas. The R&D work on icbp give some consideration-

a-The block layer,though consisting of rigid elements,behaves like a flexible layer. b-Infiltration of water having bad effect on the performance of icbp over WBM base course.

17.**K.C.Marvin :** In this paper,interlocking concrete block pavement features are to resist superimposed loading and lateral support requirements are minimised.There are many gaps in the literature on interlocking block pavement drafting of basic guidelines which is followed,will produce a sound pavement.The adopt important consideration over base and sub base, because if settlement made then overall surface may be effected by it and becomes unsetteled.The block pavement will depends upon a number of factors-

i. It is influenced by the skill, or lack of it. .

ii. Time period for produce a reliable design guide will control rate of progress.

18.**Bhimajidash Rath, et.al. :** According to this paper to corelate the properties of existings block and of those interlocking concrete paver blocks that are break rapidly regarding long term satisfactory service,to identify the test method and procedure that will make confident about the blocks are durable for desirable life span.For better performance the cement content and water content called optimum moisture content,having above and below variations from that level caused decreased in strength and density of paving blocks. Adding of fiber content about 1.5% to 2% makes blocks good enough in strength and durability.

19.**U.Rath :** In this paper the experimental investigation have done in the laboratory scale models, and effect of size, shape and compressive strength on pavement.It was realised that the block interaction under imposed load may be carry some investigation over it. The load spreading capacity of paving block surface based on the interaction of a single blocks with jointing sand to resist imposed load. The block sample test were not giving appropriate results with existing procedure and is to be very low as 13KN/mm2.

20.**Hasanan Md Nor , et.al. :** The aim of the paper is to investigate the effect of parameters like degree of slope, thickness of blocks paving and laying patterns of icbp on slopes section. Taking 3 different laying pattern and investigate over it (stretcher bond, herringe bond 90 degree and herringe bond 45 degree) and joint width 3mm,5mm,7mm was used in the test. After test it shows that herring bond 45 degree and joint width 3mm are suitable for slope section.100mm thickness block pavers is more suitable for horizontal force resistant with respect to 60mm thickness pavers blocks.

21.**Leni Stephen, Amjad Raji :** In this paper author carried out some failure reason for interlocking concrete pavement and its types of failure of icbp, mostly failure reason is improper compaction of base, not adequate thickness of base or sub base mean level. Most of the blocks fail in compressive strength test over several load (tonne), because as per IS: 15658:2006 individual paver block having 85% of specified strength must be carried 28 days curing.

Modification of pavers block by using addition of rubber pads, it is placed on the lower side of the paver block mould during curing , icbp is not laid over long span, it is suitable for small pockets roads etc. .

1. Inadequate thickness of bedding sand.
2. Improper gap filling between pavers blocks.

22. **Shajeev S , Dr. Satheesh Chandran :** was introduced about the traffic speed over the interlocking concrete block and the flexible pavement. In the research paper, the main focus on to evaluating the speed variation of vehicle over the icbp pavement and to find the level of services of icbp.

1. Spot speed data collection by manual method, radar method.
2. The speed is less compare to flexible pavement, and LOS is also less.
3. ICBP can be used as speed reduction device in speed restricted zone.

23. **Jorge B, et.al. :** This paper was also emphasis on to determine the effects of dynamic vehicle load on pavement. In this paper computer program SAPSI were used

on IBM PC/AT to evaluate the influence of dynamics loading on pavement. The main significance were come out on the stiffness and damping characteristics of the mixture on frequency, temperature, and mode of loading.

Change in the value of internal damping computed from the stiffness modulli | E* |and | G* |. Asphalt pavement life no more dynamic effect on silty clay experience while sub grade on that directly layer resting on silty clay were accumulate by the SAPSI program to determine the pavement life which lies as actual load histories for tri tandem axle suspension compare to that obtained for the same axle with a uniform static load.

24. **Sushant Shandliya Datta Kumar, et.al** : In order to ensure right option to suggested analysis of structures subjected to static and dynamic load cases and also for differences between them. The implicit method and explicit method were introduced during the analysis.

Implicit method	Explicit method
$\sum F = 0$ (static)	$\sum F = ma$ (dynamic)

The dynamic load factor (DLF) calculated based on the obtained values and it was vary from 0.5 to 20.DLF is relative in nature to the static displacement .It is not depend only on the system parameter like ,mass, stiffness and damping but also on the characteristics of load like ,duration of impulse ,rate of loading and point of operation of load. Pothole load case- scaling factor 1.58 are used to change of impact from static to dynamic load .The scaling factor for equivalent static load were found to be independent on the impulse duration and the loading rates .The equivalent static load were identified for the tested load cases which was found to vary between 1.27 to 1.58.

25.**Daniel Moazami, Ratnasamy Muniandy, Hussain Hamid and Zainuddin Md Yusoff :** According to this research estimate/experiment pavement behaviour within tire- pavement interaction by the layered linear elastic theory (KENPAVE) for ease of design procedure. In this experiment tire imprint is used instead of load over inflation pressure ratio. Marshek et al.(1985) , 8 inked tyres sample were statically loaded over a piece of paper with a load frame. The inked tyres prints on it and then read by a digitizing camera and take data were captured by the data accumulation system . Pezo et al. (1989) tyre imprint of inked tyre on a whitepaper and steel plate placed on the paper. Grid paper is used to count the imprint of tyre on the paper and to calculate the contact areas. In this paper , emphasis on to achieve realistic contact area, contact pressure over the conventional design method. Fatigue life is overestimated when using conventional method.

26**. Arian Nazeri , Reza Ziaie moayed , Hossein Ghiasinejad :**To observed the base course effect on load – settlement characteristic of sandy sub grade using plate load test were performed during the research work by them. Important parameter in this research is to be sub grade reaction coefficient. For conducting that experimental procedure a steel box of 1.35 m long ,1 m wide ,1 m deep are used. Different thickness of base course as 15 cm, 20 cm, and 30cm are suggested for that experiment, use of base course over loose sandy sub grade, the value of sub grade reaction coefficient raise from 7 N/cm^3 to 132 N/cm^3, 224 N/cm^3 and 396 N/cm^3 over thickness of 15cm, 20cm, and 30cm of base course. Relative density (95%) are laid over loose sandy, sub grade reaction coefficient (K_{30}) can be improved more than 56 times and settlement can be reduced more than 16 times.

27**. S.P.S.Rajput,** : In this paper , characteristics of mortars and concrete using crushed stone dust as fine aggregate are acceptable when compare to the natural sand as fne aggregate as per IS-383 code. The compressive strength of were increased as compared to natural sand as 9.8Mpa and the compressive strength of mortar from natural sand as 3.15 Mpa to 4.08 Mpa. According to IS -383 code and IS-2116 code allow to use of crushed stone as fine aggregate in masonary mortar. Mortar with stone dust show better workability when compare to mortar of natural sand .At 3days and 7 days best compressive strength were obtained from crushed stone dust.

28**.Samanasa Krishna Rao,** : In this research, author introduced an engineering material with unique properties as fly ash, which are used as alternative material in construction sector. Fly ash consists of silt sized particles mostly. Addition of crushed stone dust change the gradation of fly ash and increase in unit weight of the composite material. Increase in maximum dry density (MDD) from addition of crushed stone dust and fly ash and same decrease in optimum moisture content (0MC), due to stone dust CBR value were increased at combination of mixes (40% fly ash + 60% stone dust) and (60% fly ash + 40% stone dust). After the addition of 2% of lime, decrease in maximum dry density (MDD) and increase the value of CBR. The varying proportion of stone dust with fly ash of 10%, 20%, 30%, 40%,50%, 60%,70%,80%,90%.

Inferences

It was concluded that after many above researches' that how the behaviour of ICBP, types of block with respect to its thickness grade as well as its different shape of the paver block, types of bedding material and its thickness , relevant code of the ICBP for construction and design. For better performance, adding of fiber content about 1.5% to 2% makes blocks good enough in strength and durability.

Research Gap

As per IRC SP 63(2004) the guidelines for the use of ICBP where recommended value are given for the different laying situation but value of deflection with respect to applied load on ICBP is silent which are more important for better performance of ICBP because excessive deflection will lead to very rapid deterioration of Icbp leads to shortened service life.

CHAPTER 3

RESEARCH METHODOLOGY

Methods to achieve desired outcomes of this experimental test by the following experimenatal program.

1. Selection of different shape of icbp with different types of bedding materials.

2.Analysis the load carrying capacity of different shapes with respect to its different bedding material from experimental procedure.

3.Analysis The Settelment Of Bedding Surface Due To Repitation Of Loading On Different Types Of Shape With Respect To Different Types Of Bedding Materials

4.Cost comparison of icbp with asphalt pavement

5.Recommendation Of Existing Shape And Bedding Material Type With Effective Thickness

Analysis of different pavers block shape, size, and thickness with different bedding material as per guidelines for interlocking block. IRC:SP: 63-2004 "Guidelines for the use of Interlocking Concrete Block Pavement", IRC:15658-2006 "Precast Concrete Blocks For Paving Specification", IRC : 106-1990 "Guidelines For Capacity Of Urban Roads In Plain Areas", IRC:SP:49-1998 (Dry Lean Concrete), IRC:37-2018 "Guidelines For The Design Of Flexible Pavements" test will be performed.

3.1 Selection Of Different Shape Of Interlocking Concrete Paving Blocks

Interlocking Concrete Block Pavement has been found to have applications in several situations. Such as Footpaths and Side-walks, Cycle Tracks, Residential streets, Car Parks, Fuel Stations, Rural Roads through villages, Highway Rest Areas, Toll Plaza, Bus Depots, Approaches to Railway Level Rounding, Intersections, City Streets, Truck Parking Areas, Industrial floors, Urban Sections of Highways, Road Repairs during Monsoon, Container Depots, Port Wharf and Roads , Roads in high altitude are

3.1.1 In this study few shape of existing paver blocks are choose for performed the experimental procedure

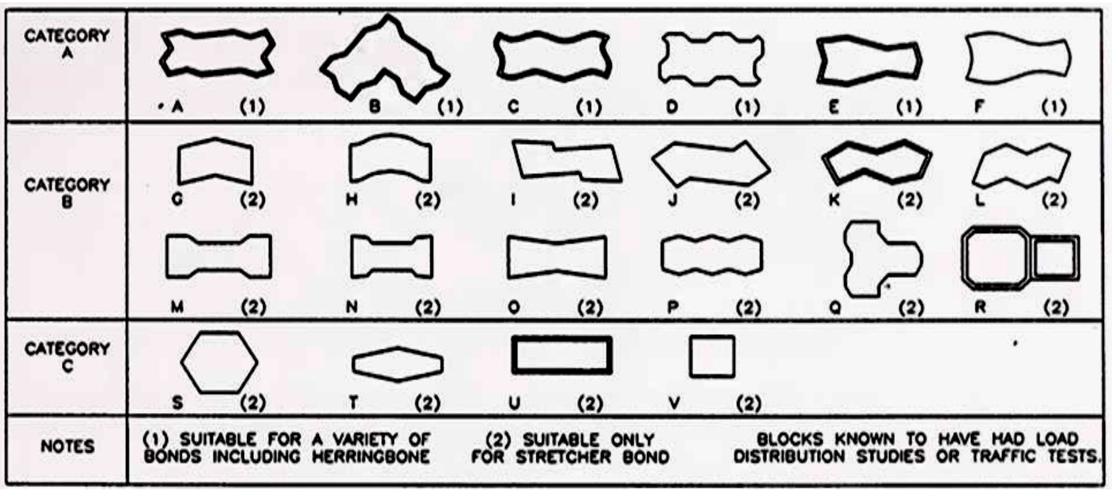


Figure.8- [Different shapes 0f blocks as per IRC:SP: 63: 2004]

Category A. These blocks are consists dentated blocks which key into each other on all four faces.

Category B. These blocks are consists dentated blocks which key into one another on two faces only.

Category C. These blocks are consists non-dentate blocks which do not key together geometricaly as previous type but structurally tendendy to assemble as interlocking pattern.

TABLE 3: Design Catalogue For Pavement thickness as per IRC:SP:63-2004

Traffic and Road Type	**Sub grade CBR(%)**		
		Above 10	**5-10**
• Cycle tracks, • Pedestrians, • Footpaths	Blocks Sand Bed Base	60 20-30 200	60 20-30
• Commercial Traffic • Axle load repetitions less than 10Mpa • Residential street	Blocks Sand Bed WBM / WMM Base Granular Sub-base	60-80 20-40 250 200	60-80 20-40 250 250
• Commercial traffic • Axle Load Repetitions 10-20 msa • Collector streets, • Industrial streets, • Bus and Truck parking areas	Blocks Sand Bed WBM / WMM Base Granular Sub-base	80-100 20-40 250 200	80-100 20-40 250 250
Commercial traffic Axle Load Repetitions 20-50 msa Arterial Streets	Blocks Sand Bed WBM/WMM Base Or WBM/WMM Base and DLC over it* Granular Sub-base	80-100 20-40 250 150 75 200	80-100 20-40 250 150 75 250

Table.3 - Different grade of pavers as per (IS 15658:2006)

Concrete classification	**Grade designation**	**Specified Compressive strength of 150mm cube after 28 days N/mm^2**	**Recommended use for blocks**
Standard concrete	M -25 –M-30	25-30	Non traffic
	M-30 – M35	30-35	Light
	M-35 – M45	35-45	Medium
	M-45 – M59	45-59	Heavy
High strength concrete		M-60 and above	Very heavy

Table.4 – Different types of pavers as per (IRC: SP: 63-2004)

SL.No	**Types Of Pavers Blocks**	**Grade of pavers block**	**Length (m)**	**Width (m)**	**Thickness (m)**	**Area of blocks (m$^{2)}$**
1	Unipaver 	M-40	0.25	0.12	0.08	0.0312
2	Round Dumble 	M-40	0.25	0.11	0.08	0.0275
3	Dumble Block 	M-40	0.23	0.10	0.08	0.023
4	L shape 	M-40	0.265	0.115	0.08	0.032

The overall dimension of blocks used in various parts of the world ranges as under:

Top surface area: 5,000 to 60,000 mm^2

Horizontal dimension not exceeding: 28 cm

Thickness: Between 60 to 140 mm

Length/Thickness: ≥ 4

The blocks should have the following dimensional tolerances:

Plan dimensions ± 2 mm

Thickness ± 3 mm

3.1.3 Laying Patterns of Blocks

The blocks can be placed to different bonds or patterns depending upon requirement. Some popular bonds commonly adopted for block paving are:

(i) Stretcher or running bond

(ii) Herringbone bond

(iii) Basket weave or parquet bond

With the help of gauges, the joint width specification (2 to 4 mm) should be checked in the first few square metres, where it should be ensured that the block alignment is correct. Under no circumstances should the blocks be forced or hammered into the bedding sand at this stage of laying. Where space does not permit use of a larger segment, use premixed concrete or a sand-cement mortar instead. The control over alignment, laying pattern and joint widths can be maintained by the use of chalked string lines, at about 5 m intervals.

Figure.9(a) Unipaver block

Figure.9(b) Round Dumble

Figure.9(c) Round dumble block

The following procedures were performed to satisfy recommended guidelines to ensure quality and test procedure.

a. Visual inspection

All the 10 blocks shall be inspected for visual defects. Out of the 10blocks, 5 blocks shall be subjected to the test for measurement of dimensions, chamfer, aspect ratio, plan area, wearing surface area and deviation from squareness.

b. Water Absorption test.

Weight of dry sample of pavers blocks and takes wet weight of that sample during test period. Wet weight not more than 5% of total mass of dry weight. Time period may be 24 hours for test.

Absorption % = (A –B)/B×100

A =wet weight

B =dry weight

weight of dry pavers block 3000 grams and after test it becomes 3050 grams then its means 50grams of water absorbed by the pavers blocks sample.

c. CBR value for sub grade layer of pavement.

The desired CBR value may be determined as per the following procedure which is in the approach presented earlier in an Indian Roads Congress publication.

An area of study limited to Lucknow city which are lies in indo plain region having more than 5 % CBR value for roads design to carry more than 450 commercial vehicles per day.[34] As per clause 6.6 and clause 6.7 of IRC;SP;63-2004, wherever the sub grade is weak (having a CBR value below 5) use of bound granular materials, like, cement treated crushed rock, requiring a relatively thinner base, should be preferred while for high strength sub grades, unbound crushed rock can be used.

d. **Flexural strength of different shape and thickness by using different bedding materials shall be calculated as follows:**

$$fu = 24 P / bd^2$$

Where

fu = Flexural strength (N/mm2)

p = Maximum load (N)

b = Width of the block (mm)

d = Thickness of the block (mm)

Target strength for interlocking concrete block; the minimum average 28 days' compressive strength shall be determined as per the requirements provided in table 3 of IS 15658:2006.

Target strength = f_{ck} + K S

= 40 + 0.5 × 5

= 42.5 N/mm2

K is a constant for defective products = 0.825 for concrete paver blocks (rounded off to nearest 0.5 N/mm2) [IS 15658:2006]

K= 1.65 for normal concrete cubes as per (IS 10262:2009)

Standard deviation (S) = 3.5 N/mm^2 for small number of blocks per cycle with pressure type machine.

= 7.0 N/mm^2 for large number of blocks per cycle with vibration type concrete paver block. (Dowson 1980)

= 5 N/mm^2 for normal concrete cubes (IS:10262-2009)

3.2 Selection Of Different Types Of Bedding Materials and Joint Sand

Bedding material: The physical properties of bedding materials, which include load spreading properties to reduce stresses on the sub grade and desired drainage characteristics, have an important bearing on the performance of a block pavement. Although, local availability and economics generally dictate the choice of bedding material at the design stage, the commonly used materials considered suitable for bedding material. It is well established that if proper attention is not paid to the quality of bedding sand, and if the thickens of the bedding sand layer is not uniform enough, serious irregularities in surface profile can result; excessive differential deformation and rutting can occur early in service life of the block pavement. The fine aggregate shall meet the requirements of IS 383. Generally, for high strength, a fine aggregate of coarser size is preferred (Zone I or Zone II), due to availability of high fines content from the cementitious materials.

Table 5.IS-383 Sieve sized gradation

IS Sieve Size	Percentage passing
9.52mm	100
4.75mm	95 – 100
2.36mm	80 - 100
1.8mm	50 – 95
600micron	25 – 60
300micron	10 – 30
150micron	0 – 15
75micron	0 – 10

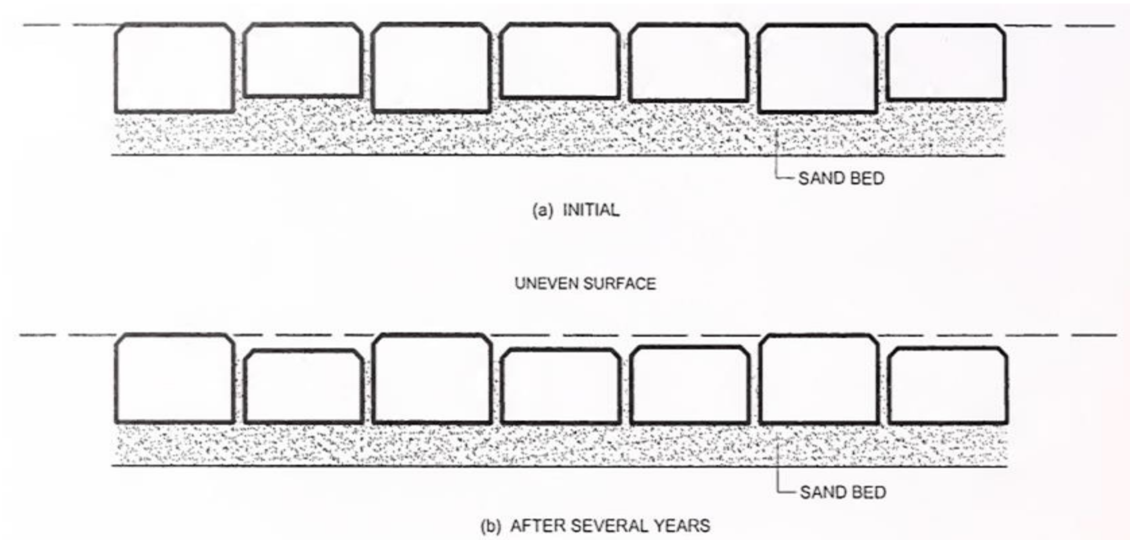


Figure.10 Uneven thickness effect

Table.6 Thickness of different bedding material

Bedding Material	Same thickness for all types
1. Natural coarse sand	25mm-40mm
2. Stone dust	25mm-40mm
3. fly ash +stone dust (25:75) with poly propylene fibre at varying percentage	25mm-40mm

Compaction: For compaction of the bedding sand and the blocks laid over it, vibratory plate compactors are used over the laid paving units; at least two passes of the vibratory plate compactor are needed. Such vibratory compaction should be continued till the top of each paving block is level with its adjacent blocks. It is not good practice to leave compaction till end of the day, as some blocks may move under construction traffic, resulting in the widening of joints and comer contact of blocks, which may cause spalling or cracking of blocks. There should be minimal delay in compaction after laying of the paving blocks to achieve uniformity of compaction and retention of the pattern of laying; however, compaction should not proceed closer than 1 m from the laying face, except after completion of the pavement.

(i) Natural coarse sand : It is also a fine aggregate having ideal shape and size which are used in concrete. Its particles are well–rounded and are usually nearly spherical, due to spherical shape in nature decrease the percentage of voids in concrete and no additional paste are required to fill the voids. The main source is river and say river sand.

Figure.11 Natural coarse sand

Gradation analysis and Fineness Modulus of fine aggregate (Natural Coarse Sand)

Table7. As per IS.383.1970 and IS.2386.1.1963 recommended sieve set are used for analysis of fine aggregate as bedding material.

Sieve size Distribution	**Retained Weight (gm)**	**Retained percent (%)**	**Cumulative Retained percent (%)**	**Passing percent (%)**
10 mm	0.0	0.0	0.0	100
4.75 mm	41	4.1	4.1	95.9
2.36 mm	89	8.9	13.0	87.0
1.18 mm	149	14.9	27.9	72.1
0.6mm	348	34.8	62.7	37.3
0.3mm	370	37.0	99.7	0.3
0.15mm	3.0	0.3	100	0.0
0.075mm	0.0	0.0	0.0	0.0
PAN	0.0	0.0	0.0	0.0
			∑F.M = 307/10 = 3.07	

As per IRC 383-1970 recommended sieve distribution- the bedding material are lies in Grading Zone 2.

Fineness Modulus of fine aggregate = ∑F.M /100

$$\sum F.M = 307/100 = 3.07$$

BEDDING MATERIAL TYPE	FINENESS MODULUS RANGE
Fine Sand	2.2 – 2.6
Medium Sand	2.6 – 2.9
Coarse Sand	2.9 – 3.2

Table .8 Fineness Modulus Range

(ii) Stone Dust: Conventional construction material like fine aggregates is becoming progressively scarce on account of environmental concerns as well as legal restrictions on quarrying while the construction activity has expanded phenomenally. This has shifted focus from large scale use of conventional aggregates to use of local, recycled and engineered marginal fine aggregates in construction. It is recognized that research as well as performance trials have not been very extensive in India for some of the new materials but these have been included in the guidelines in the light of extensive performance reports and current practice in Australia, South Africa and other countries with due safeguards in design for heavy axle loads. Some trials in India have performed well (Annex XI).IRC:37-2012Accordingly, this guidelines of IRC:37 incorporates some of the new and alternate materials in the current design practices. A designer can use his sound engineering judgment consistent with local environment using a semi-mechanistic approach for design of pavements.

Figure.12 stone dust as bedding material

Figure13 (a) stone dust

Figure.13 (b) stone dust used in experimental program

Gradation analysis and Fineness Modulus of fine aggregate (Stone Dust)

Sieve size Distribution	**Retained Weight (gm)**	**%age Weight Retained**	**Cumulative weight Retained(%)percent**	**Passing percent (%)**
10 mm	0	0	0	100
4.75 mm	15	1.4	1.4	98.6
2.36 mm	95	9.5	10.9	89.1
1.18 mm	298	29.8	40.7	59.3
0.6mm	277	27.7	68.4	31.6
0.3mm	154	15.4	83.8	16.2
0.15mm	123	12.3	96.1	3.9
0.075mm	39	3.9	100	0
PAN	0.0	0.0	0.0	0
			∑F.M=301.3 /100 = 3.013	

As per IRC 383-1970 recommended sieve distribution - the bedding material are lies in Grading Zone 2.

Fineness Modulus of fine aggregate = ∑F.M /10

=301.3/100

F M = 3.013

(iii). Mixture Of Stone Dust And Fly Ash (75:25) With Varying Percentage Of Polypropylene Fiber.

Fly Ash : Pulverized fuel ash is a residue resulting from the combustion of ground or powdered or crushed bituminous coal or sub-bituminous coal (lignite). About 80 percent of the total ash is finely divided and get out of boiler along with flue gases and is collected by suitable technologies. This ash generally and in this standard is termed as fly ash. It is sometimes referred as chimney ash and hopper ash. The balance about 20 percent of ash gets collected at the bottom of the boiler and is taken out by suitable technologies and is referred as bottom ash. Fly ash is collected and stored in dry condition. When fly ash and/or bottom ash is carried to storage or deposition lagoon or pond in the form of water slurry and deposited, it is termed as pond ash. Whereas, if fly ash and/or bottom ash is carried to a storage or deposition site in dry form and deposited, it is termed as mound ash. As per IS: 3812-2003 this standard was first published in 1966 in three parts to cater to the requirements of fly ash for three specific uses: Part 1 covering use of fly ash as a pozzolana, Part 2 covering use of fly ash as an admixture for concrete, and Part 3 covering use of fly ash as fine aggregate for mortar and concrete.

Figure.14 Fly Ash Sample

Data For Mix Proportioning : The following data are required for mix proportioning of a particular grade of concrete:

a) Grade designation;

b) Type of cement, and grade of cement (if applicable)

c) Maximum nominal size of aggregated)

d) Minimum cement/cementitious materials (fly ash) content and maximum water-cement/ cementitious materials ratio to be adopted; or Exposure conditions as per Table -3 and Table 5 of IS 456;

e) Workability required at the time of placement;

f) Transportation time;

g) Method of placing;

h) Degree of site control (good/fair) or value of established standard deviation, if any;

i) Type of coarse aggregate (angular/sub angular/ Licensed to IRICENLIB library@iricen.gov.in 2 IS 10262 : 2019 gravel with some crushed particles/rounded gravel/manufactured coarse aggregate);

j) Type of fine aggregate (natural sand/ crushed stone or gravel sand/manufactured sand/ mixed sand);

k) Maximum cement content;

l) Whether a chemical admixture shall or shall not be used and the type of chemical admixture and the extent of use;

m) Whether a mineral admixture shall or shall not be used and the type of mineral admixture and the extent of use; and

n) Any other specific requirement like early age strength requirements.

NOTE — Suitable reduction in water cement or water cementinious material ratio shall be done after the mix has been finalized based on trial mixes, to achieve the specific requirement of high early strength, if any. The reduced ratio shall be fixed based on trials for the required early strength. These trials shall be carried out after recalculating all the mix proportions.

Poly Propylene Fiber: Poly propylene Fibers is a modern textile used for upholstery, industrial, and manufacturing applications. It's soft, lightfast, and easy to clean because polypropylene has no active dye sites. It's also super strong and can be cleaned with bleach; even with dark colors.

Figure .15 Poly Propylene Fiber

Calculation of Cement/Cementitious Materials Content (Fly Ash):

1. The cement and supplementary cementitious materials content per unit volume of concrete may be calculated from the free water-cement ratio (see 5.1 of IS : 10262-2019) and the quantity of water per unit volume of concrete. In certain situations, while using part replacement of cement by fly ash, ground granulated blast furnace slag (GGBS), silica fume, and other mineral admixtures, increase in cementitious materials content may be warranted, particularly if fly ash is 20 percent or more. The decision on increase in cementitious materials content and its percentage may be based on experience and trials; or the cementitious materials content so calculated may be increased by 10 percent for preliminary trial. The water-cementitious materials ratio shall be recalculated, based on the increased cementitious materials content, as per Table 5 of IS 456. The cementitious materials content so calculated shall be checked against the minimum content for the requirements of durability as per IS 456 or as specified and greater of the two values may be adopted. The maximum cement content shall be in accordance with IS 456 or as specified.

2. The percentage of fly ash/GGBS to be used has to be decided based on the project requirement and the quality of these materials. From previous sieve analysis of fine aggregate as per IS-383 were confirmed their properties of all the bedding material. But in case of fly ash not applicable that type of sieve set to perform the sieve analysis

Table.9 Recommended Dosages of Mineral Admixtures Materials for High Strength Mixes (Clause 6.2.6) IS :10262-2019

Sl .No.	Mineral Admixtures	Recommended Dosages, Percentage by Mass of Total Cementitious Materials
i)	Fly ash	15 – 30
ii)	Ground granulated blast furnace slag	25 – 50
iii)	Metakaoline	5- 15
iv)	Silica fume	5-10

Figure .15 mixture of poly propylene, stone dust and fly ash

3.3 Axle load carrying capacity: This is the maximum load that your vehicle's front and rear axles can carry as specified by the manufacturer. You will usually find these figures in the owner's manual. The combined gross axle weights usually exceed the GVM, to provide a safety margin.

Calculate Axle Weight-

i) Add the total weight of the load you will be carrying to the total trailer weight.

ii) Divide the total weight of the load and trailer by the total number of tandem axles.

iii) Include the load bearing axle in your count.

iv) write down the total weight of your tractor or pickup.

The maximum allowed axle load on the roads is called legal axle load. For highways the maximum legal axle load in India, specified by IRC, is 10 tonnes.

Standard axle load: It is a single axle load with dual wheel carrying 80 KN load and the design of pavement is based on the standard axle load.

Table.10 Different Axle Load As Per different Authorities

Authority	Single axle (Tonnes)	Tandem axle (Tonnes)
1. AASTHO	9.0 Ton	14.5 Ton
2. BS EN	10.00 Ton	-
3. IRC	10.20 Ton	18.00 Ton

1. AASHTO – The American Association of State Highway and Transportation Officials.
2. BS EN - British Standard European Norm
3. IRC - Indian Road Congress

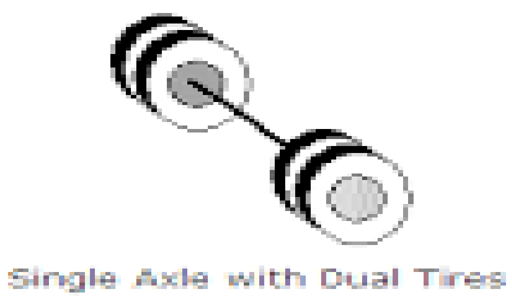


Figure .16 Single Axle Dual Tyre

Standard axle - 8 Ton (80KN), the single axle load is with dual wheel carrying 80 KN load and the design of pavement is based on the standard axial load. Assume

2.55Ton or approx 3.0 Ton Load on each side of front axial tyre. From these load carrying capacity value we may calculated as per procedure.

EXPERIMENTAL PROGRAM

ASSUMPTION FOR EXPERIMENTAL PROGRAM

- Beneath the bedding material, rigid surface are considered during entire experimental test of test bed.
- The dynamic impact events can be convert into equivalent static load by the scaling factor (sf) 1.58. [24]
- The interlocking block paver's thickness as 80 mm for arterial road is used for this test.
- Thickness of bedding material will be taking in (thickness + 5mm more for loose bedding) at every stage of selection.

Figure. 17 tandem axle combination

- As per IRC for axle load

  18 TON - Tandem Axle

  3 axle = 18 / 3

  = 6 TON on each axle

  From general consideration 3 ton on front tyre of each side..

  Load Type 1= 29.42 KN

  Load Type 2 = 29.42 KN × $1.58_{(SF)}$

  = 46.48 KN

  Because load configuration may be applied as 1:2 on the chassis of the vehicles

To build the test sections of Interlocking concrete block pavement, a test bed [41cm×30cm×15cm] prepared for testing the entire experimental procedure. Several loading pattern were installed manually to measure the performance of the pseudo experimental pavement over the different bedding material with its distinguish thickness of bedding material during construction. Take tyre imprint measurement of tandem axial trailer type vehicle from field survey, length of imprint is 230 mm and width is 212 mm ,thickness is 220 mm from ground surface to lowest of the rim surface is laid over the different Standard specimen block size is 250mm in length and width is 120mm thickness is 80mm and length 265mm Width12.5mm thickness 80mm and Length 250 mm Width 110 mm and Thickness 80 and Length 210 mm Width 100 mm thickness 80 mm and Length 210 mm Width 110 mm thickness 80mm interlocking concrete pavers blocks were installed manually spreading on the different types of bedding material of thickness (25mm to 40mm) and filling joints by joints sand of 2 mm to 5 mm.

Figure.18 (TEST BED)

Then we take a iron sheet or 4 mm thick plywood sheets of size larger than the specimens by a gap of 5 mm from all edges of the specimen shall be used for capping the specimens. and placed over the test bed as actual width measurement of tyre imprint say (full block + half cut into horizontal length 147mm+72.5mm) and applied load on test bed as Load type 1 (29.4KN) and Load type 2 (29.42 KN *1.58= 46.48 KN) from UTM machine.

Measurement Of Tyre Tread : Length of Imprint is 230 mm,

Width is 212 mm,

Thickness is 220 mm

Figure .19- Tyre Tread Of Tandem Axial Type Vechicle.

Figure . 20- Different shape of blocks with different loading pattern

Figure.21- Bedding Materials (stone dust crusher and natural coars

METHOD FOR DETERMINATION OF COMPRESSIVE STRENGTH

APPARATUS

l.l Testing Machine: The apparatus shall comprise a compression testing machine which shall be equipped with two steel bearing blocks for holding the specimen. It is desirable that the blocks have a minimum hardness of 60 (HRC)and a minimum thickness of .25mm. The block on top through which load is transmitted to the specimen shall be spherically seated. The block below on which the specimen is placed shall be rigidly fitted. When the bearing area of the steel blocks is not sufficient to cover the bearing area of the paver block specimen, two steel bearing plates meeting the requirements of shall be placed between the steel plates fitted on the machine and the specimen.

l.2 Steel Bearing Block and Plates: The surfaces of the steel bearing blocks and plates shall not depart from the plane by more than 0.025 mm in any 15 mm dimension. The centre of the sphere of the spherically seated upper bearing block shall coincide with the centre of the bearing surface. If a bearing plate is used, the centre of the sphere of the upper bearing block shall be on a line passing vertically through the centroid of the specimen bearing face. The spherically seated block shall be held closely in its seat, but shall be free turn in any direction. The diameter of the face of the bearing blocks shall be at least 150 mm. When steel plates are employed between the steel bearing blocks and the specimen, the plates shall have a thickness equal to at least one-third the distance from the edge of the bearing block to the most distant corner of the specimen. In no case shall the plate thickness be less than 12mm.

SPECIMENS

The five specimens tested as per Annexes C and 0 shall be used for the tests.

CAPPING OF SPECIMENS

- The bearing surfaces of the specimens shall be capped by one of the methods described in Clauses C-3.1 and C-3.2 of Appendix C of IS: 2185 (Part l)-1979,

- Alternatively, 4 mm thick plywood sheets of size larger than the specimens by a margin of at least 5 mm from all edges of the specimen shall be used for capping the specimens

- When blocks with surface relief features have to be tested; their surfaces shall be ground to plainness before capping and testing.

PROCEDURE

1. The dimensions and plan areas of the blocks shall be determined as described in Annex B. The blocks shall be stored for 24+4 hours in water maintained at a temperature of (20+5) °C. The bearing plates of the testing machine shall be wiped clean. The specimen shall be clamped between the plates in such a way that the axes of the specimen are aligned with those of the bearing plates.

2 The load shall be applied without shock and increased continuously at a rate of 15+3N/mm^2/minute until no greater load can be sustained by the specimen occurs.

3. The maximum load applied to the specimen shall be noted in N.

CALCULATION

- The apparent compressive strength of individual specimen shall be calculated by dividing the maximum load (in N) by the plan area (in mm2).
- The corrected compressive strength shall be calculated by multiplying the apparent compressive strength by the appropriate correction factor from Table below. The strength shall be expressed to the nearest 0.1 N/mm2.
- Correction factors for thickness and chamfer of paver block for calculation of compressive strength (ClauseE-5) for other thickness of paver blocks between 60 mm and 120 mm, linear extrapolation of correction factor shall be made.

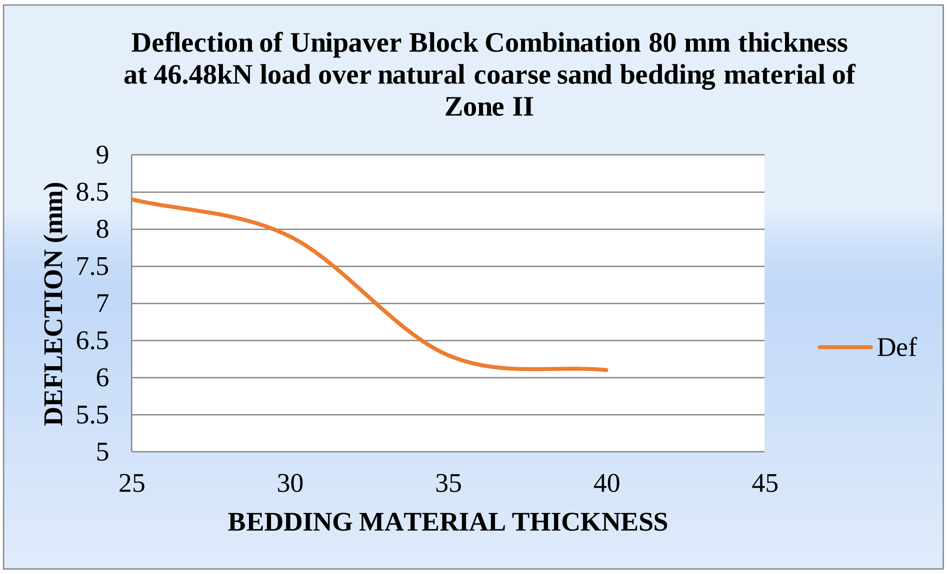
Figure 22 (UTM at central workshop Integral University)

The entire procedure can be perform on UTM for testing pseudo interlocking concrete block pavement bedding to achieve realistic loading interpolation for settlement of bedding material with respect to loading on different shape during desired loading as per irc recommendation.

CHAPTER-4
RESULT AND DISCUSSION

COMBINATION1: **Table11.**Unipaver block of 80mm thickness Combination over natural coarse sand (Zone II) bedding material

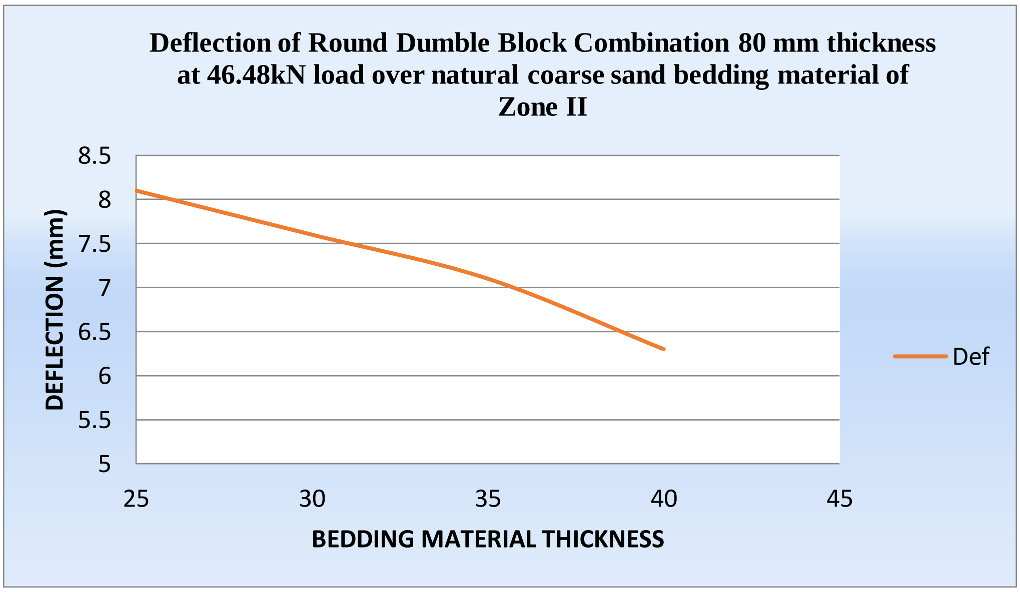
TYPE OF BEDDING MATERIAL (B.M)	BEDDING MATERIAL (B.M) THICKNESS in MM	TYPE OF PAVER BLOCK	LOAD TYPE-1 in KN	EQUIVALENT STATIC LOAD TYPE-2 in KN L 1×1.58sf	SETTELMENT OF TEST BED DUE TO LOADING in MM
1.Coarse Natural Sand	**25**	UNIPAVER	**29.42**	**46.48**	**8.4**
2.Coarse Natural Sand	**30**	UNIPAVER	**29.42**	**46.48**	**7.9**
3.Coarse Natural Sand	**35**	UNIPAVER	**29.42**	**46.48**	**6.3**
4.Coarse Natural Sand	**40**	UNIPAVER	**29.42**	**46.48**	**6.1**



Graph.1 Load Vs Deflection of unipaver over natural coarse sand

COMBINATION II: Table 12, Round Dumble Block Combination Over Natural coarse Sand (Zone II) Bedding Material

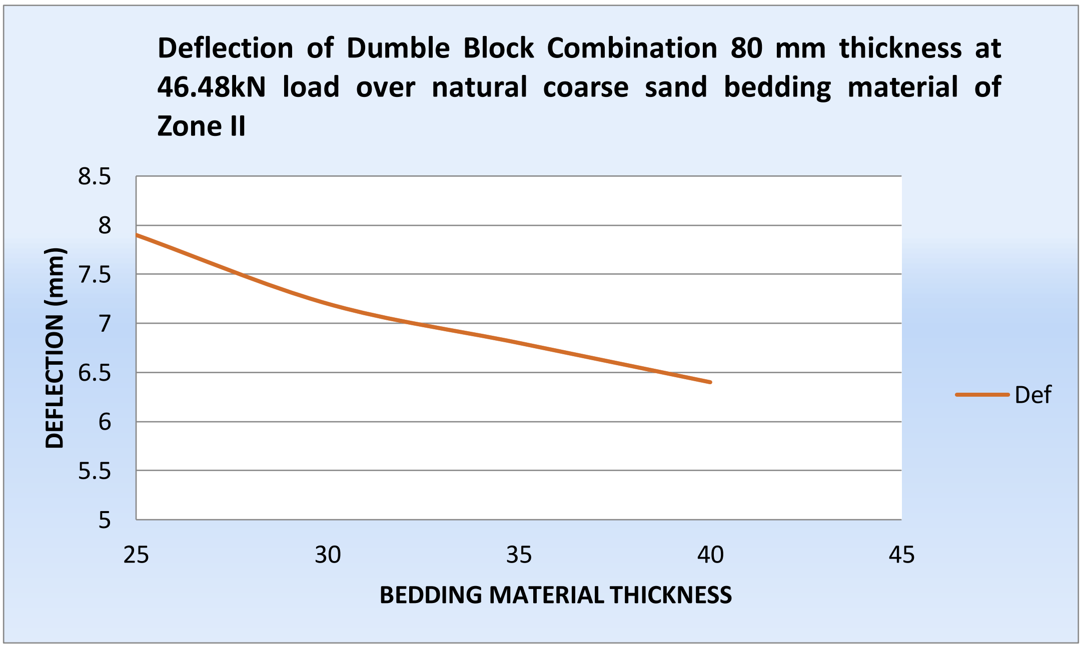
TYPE OF BEDDING MATERIAL (B.M)	**BEDDING MATERIAL (B.M) THICKNESS in MM**	**TYPE OF PAVER BLOCK**	**LOADING TYPE-1 in KN**	**EQUIVALENT STATIC LOADING TYPE-2 in KN L1×1.58 sf**	**SETTELMENT OF TEST BED DUE TO LOADING in MM**
1. Coarse Natural Sand	**25**	Round Dumble	**29.42**	**46.48**	**8.1**
2.Coarse Natural Sand	**30**	Round Dumble	**29.42**	**46.48**	**7.6**
3.Coarse Natural Sand	**35**	Round Dumble	**29.42**	**46.48**	**7.1**
4.Coarse Natural	**40**	Round Dumble	**29.42**	**46.48**	**6.3**



Graph.2 Load Vs Deflection over natural coarse sand

COMBINATION III: Table13, Dumble Block Combination 80mm thickness Over Natural coarse Sand (Zone II)

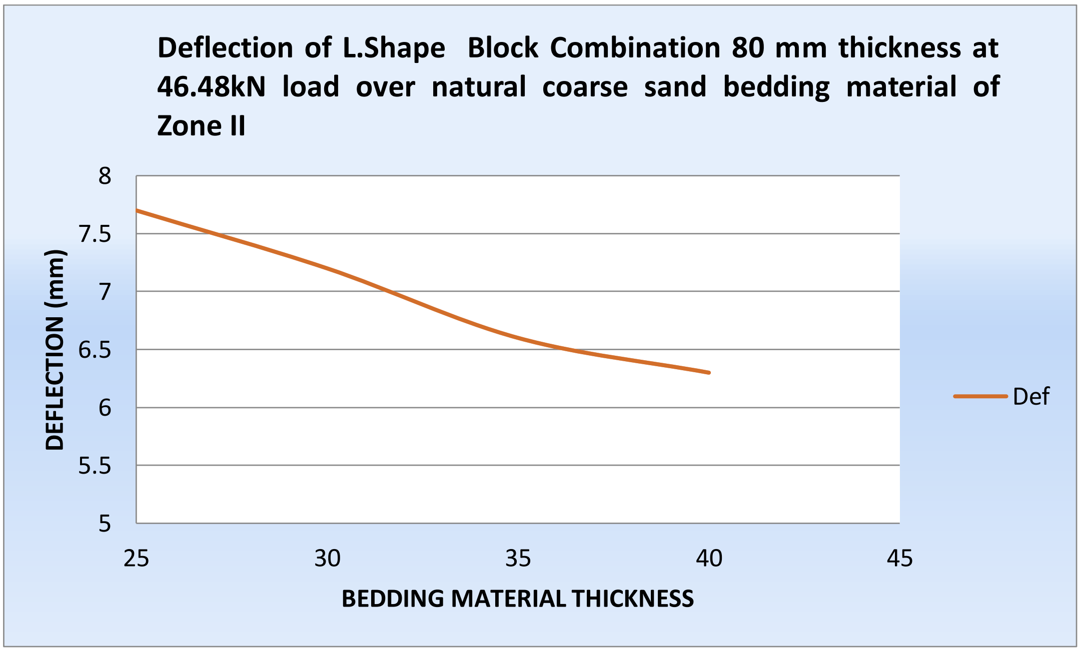
TYPEOF BEDDING MATERIAL (B.M)	BEDDING MATERIAL (B.M) THICKNESS in MM	TYPE OFPAVER BLOCK	LOADING TYPE-1 in KN	EQUIVALENT STATIC LOADING TYPE-2 in KN L 1×1.58$_{sf}$	SETTELMENT OF TEST BED DUE TO LOADING in MM
1.CoarseNatural Sand	**25**	Dumble Block	**29.42**	**46.48**	**7.9**
2.Coarse Nature Sand	**30**	Dumble Block	**29.42**	**46.48**	**7.2**
3.Coarse Nature Sand	**35**	Dumble Block	**29.42**	**46.48**	**6.8**
4.Coarse Nature Sand	**40**	Dumble Block	**29.42**	**46.48**	**6.4**



Graph.3 Load Vs Deflection over Natural coarse sand

COMBINATION IV: Table14, L- Shape Block Combination 80mm thickness Over Natural coarse Sand (Zone II)

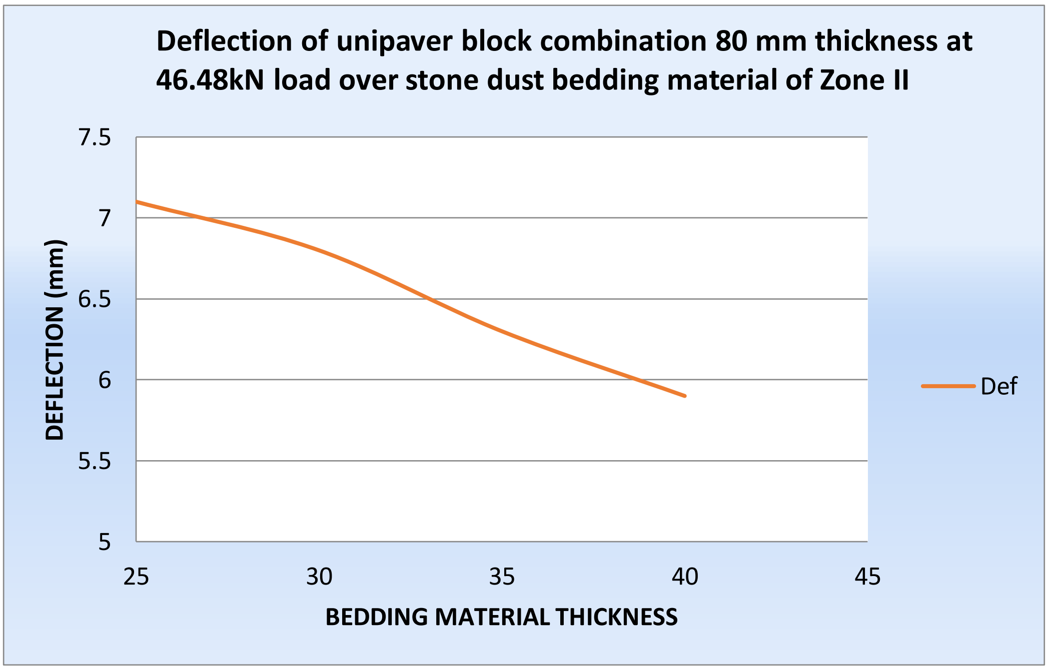
TYPE OF BEDDING MATERIAL (B.M)	BEDDING MATERIAL (B.M) THICKNESS in MM	TYPES OF PAVER BLOCK	LOADING TYPE-1 in KN	EQUIVALENT STATIC LOADING TYPE-2 in KN L 1×1.58$_{sf}$	SETTELMENT OF TEST BED DUE TO LOADING in MM
1. STONE DUST	**25**	L SHAPE	**29.42**	**46.48**	**8.3**
2.STONE DUST	**30**	L SHAPE	**29.42**	**46.48**	**7.4**
3.STONE DUST	**35**	L SHAPE	**29.42**	**46.48**	**7.1**
4.STONE DUST	**40**	L SHAPE	**29.42**	**46.48**	**5.9**



Grahp.4 Load Vs Deflection on natural sand

COMBINATION V Table15 unipaver block combination of 80mm thickness over Stone Dust (Zone II) bedding material

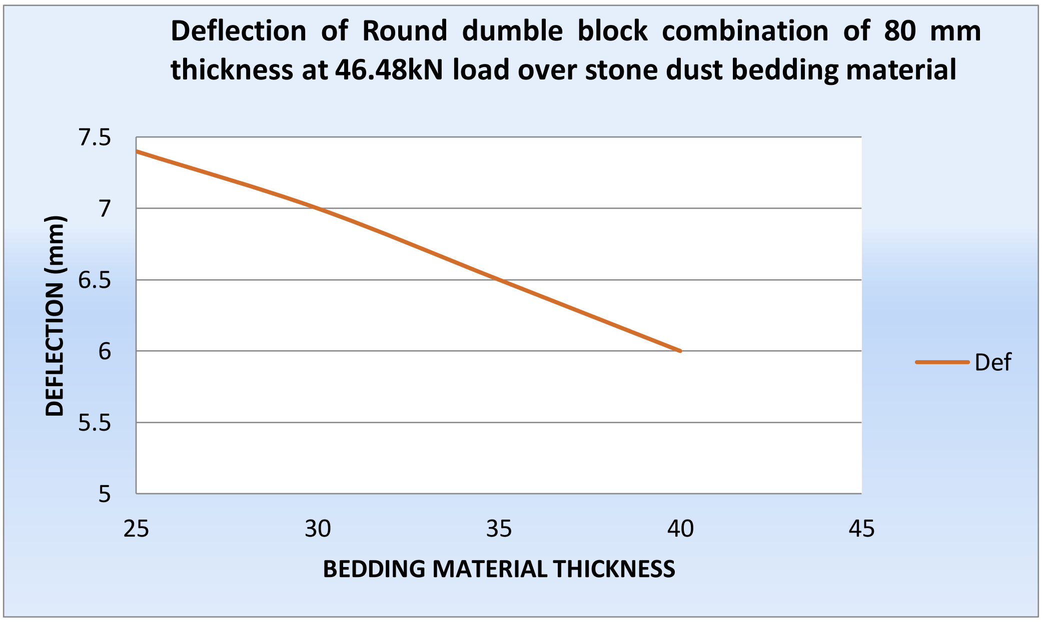
TYPE OF BEDDING MATERIAL (B.M)	BEDDING MATERIAL (B.M) THICKNESS in MM	TYPE OF PAVER BLOCK	LOADING TYPE-1 in KN	EQUIVALENT STATIC LOADING TYPE-2 in KN L 1×1.58$_{sf}$	SETTELMENT OF TEST BED DUE TO LOADING in MM
1.STONEDUST	**25**	UNIPAVER	**29.42**	**46.48**	**7.1**
2.STONEDUST	**30**	UNIPAVER	**29.42**	**46.48**	**6.8**
3.STONE DUST	**35**	UNIPAVER	**29.42**	**46.48**	**6.3**
4.STONE DUST	**40**	UNIPAVER	**29.42**	**46.48**	**5.9**



Graph .5 Load Vs Deflection over stone dust

COMBINATION VI: Table.16 Round Dumble Combination of 80mm thickness over Stone Dust (Zone II) bedding material

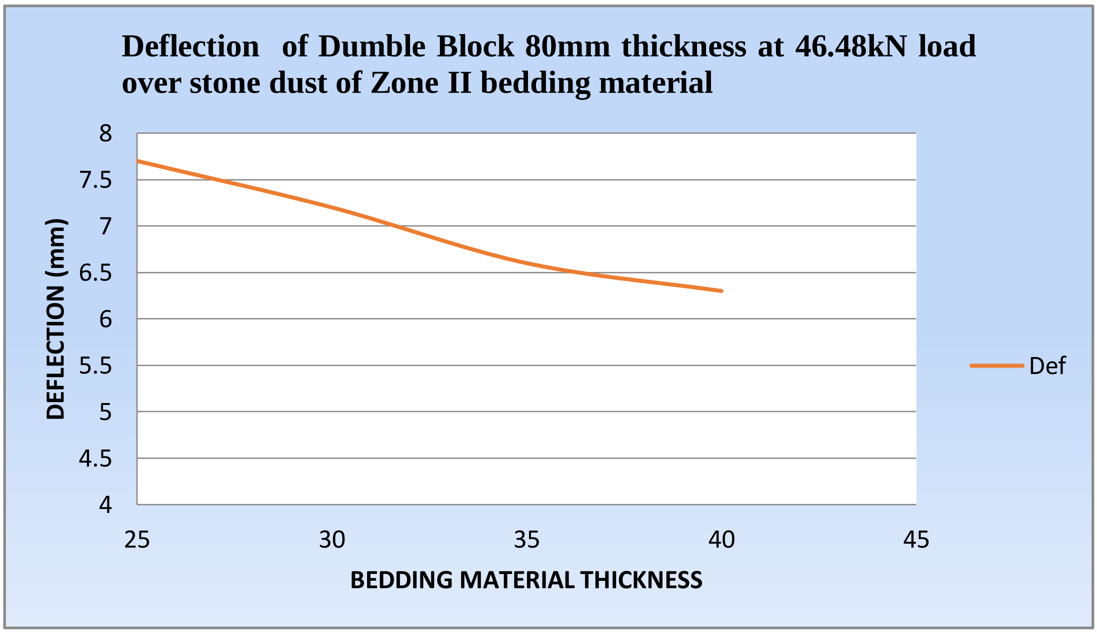
TYPE OF BEDDING MATERIAL (B.M)	BEDDING MATERIAL (B.M) THICKNESS in MM	TYPES OF PAVER BLOCK	LOADING TYPE-1 in KN	EQUIVALENT STATIC LOADING TYPE-2 in KN L 1×1.58$_{sf}$	SETTELMENT OF TEST BED DUE TO LOADING in MM
1. STONE DUST	**25**	Round Dumble	**29.42**	**46.48**	**7.4**
2.STONE DUST	**30**	Round Dumble	**29.42**	**46.48**	**7.0**
3.STONE DUST	**35**	Round Dumble	**29.42**	**46.48**	**6.5**
4.STONE DUSt	**40**	Round Dumble	**29.42**	**46.48**	**6.2**



Graph.6 Load Vs Deflection over stone dust

COMBINATION VII:-Table.17 Dumble Block Combination of 80mm thickness over Stone Dust (Zone II) bedding material

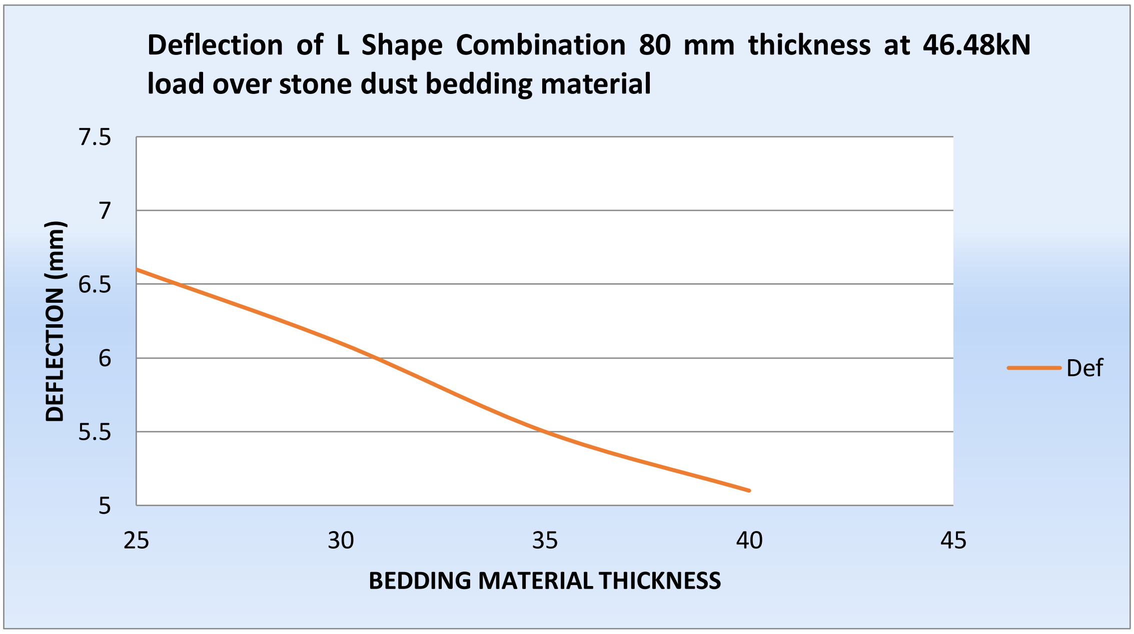
TYPE OF BEDDING MATERIAL (B.M)	BEDDING MATERIAL (B.M) THICKNESS in MM	TYPES OF PAVER BLOCK	LOADING TYPE-1 in KN	EQUIVALENT STATIC LOADING TYPE-2 in KN L 1×1.58sf	SETTELMENT OF TEST BED DUE TO LOADING in MM
1. STONE DUST	**25**	Dumble Block	**29.42**	**46.48**	**7.7**
2.STONE DUST	**30**	Dumble Block	**29.42**	**46.48**	**7.2**
3.STONE DUST	**35**	Dumble Block	**29.42**	**46.48**	**6.6**
4.STONE DUST	**40**	Dumble Block	**29.42**	**46.48**	**6.3**



Graph .7 Loads Vs Deflection over stone dust

COMBINATION VIII: Table.18 L Shape Combination Over Stone Dust of 80mm thickness Over Stone dust (Zone II)

TYPE OF BEDDING MATERIAL (B.M)	**BEDDING MATERIAL (B.M) THICKNESS in MM**	**TYPES OF PAVER BLOCK**	**LOADING TYPE -1 in KN**	**EQUIVALENT STATIC LOADING TYPE-2 in KN L 1×1.58$_{sf}$**	**SETTELMENT OF TEST BED DUE TO LOADING in MM**
1. STONE DUST	**25**	L SHAPE	**29.42**	**46.48**	**6.6**
2.STONE DUST	**30**	L SHAPE	**29.42**	**46.48**	**6.1**
3.STONE DUST	**35**	L SHAPE	**29.42**	**46.48**	**5.5**
4.STONE DUST	**40**	L SHAPE	**29.42**	**46.48**	**5.1**



Graph.8 Load Vs Deflection over stone dust

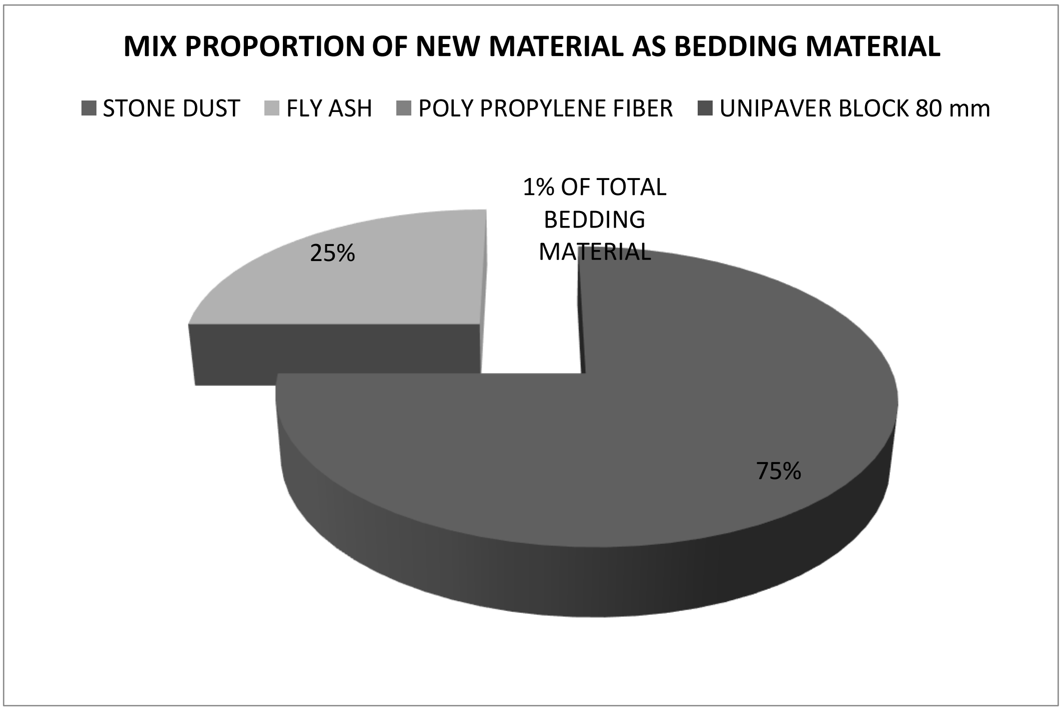
Conclusion Drawn Based On Using Stone Dust and Natural Sand As Bedding Material Of Thickness 25mm to 40mm

After analysis of all the load verses deflection value against applied load ,minimum thickness of different bedding material say(25mm) showing more deflection compare to other increasing thickness value because after applying load pavers block can displace the material which are thin. Apart from these various graph of interlocking pavers block with respect to bedding materials show deflection decreaes with increases of bedding thickness. From entire data best suit is unipaver because it show less deflection on 35 mm and 40 mm thickness of bedding materials both (natural sand and stone dust) in all types of pavers shape.

New Bedding Material Introduce For Experimental Test

COMBINATION IX: Table.19 (A) Combination of new bedding material for load carrying capacity over specific thickness of material.

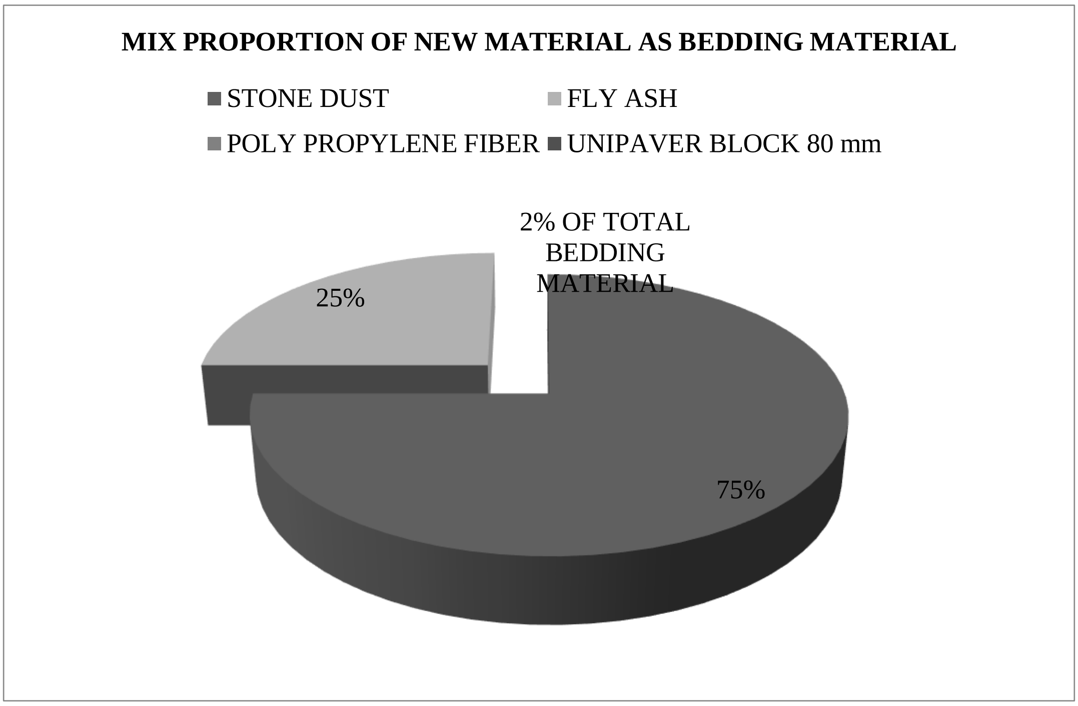
Bedding material types	**Thickness of material**	**Mix proportion**	**Deflection**
Fly ash + stone dust + poly propylene fiber	25mm	25% + 75% with 1% of poly propylene fiber is being mixed by weight of bedding material.	6.5 mm
		Unipaver types of 80 mm block	



Graph .9 New Material Mix Of 25 mm Thickness

COMBINATION X: Table.19 (B) Combination of new bedding material for load carrying capacity over specific thickness of material.

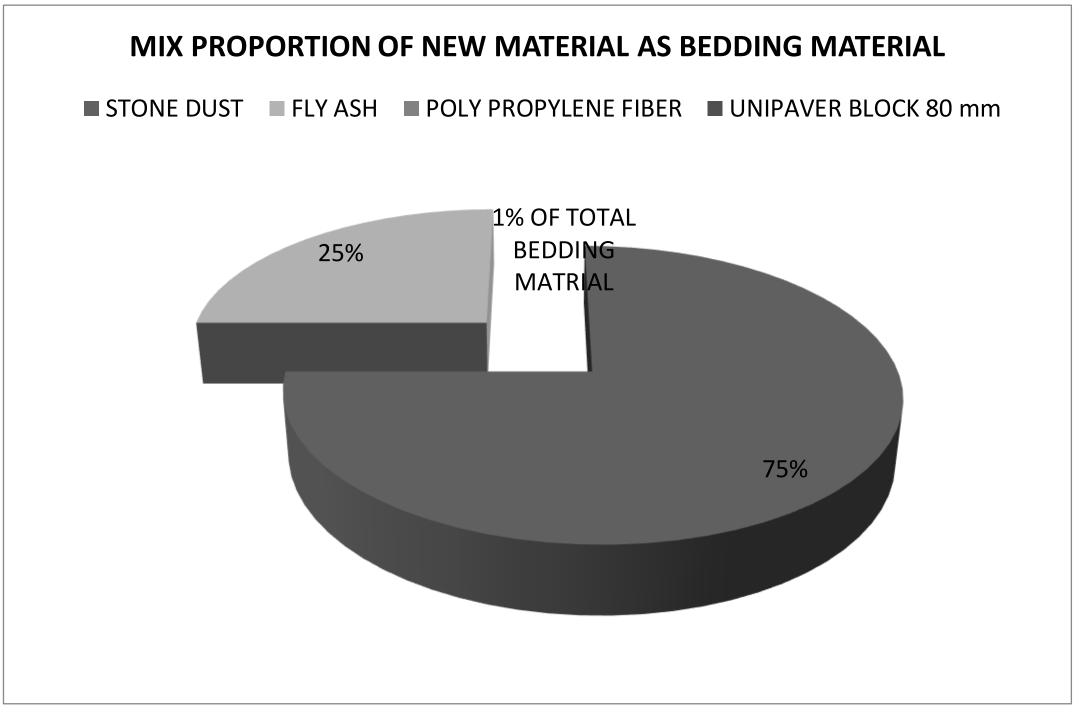
Bedding material types	Thickness of material	Mix proportion	Deflection
Fly ash + stone dust + poly propylene fiber	25mm	25% + 75% with 2% of poly propylene fiber is being mixed by weight of bedding material.	6.3 mm
		Unipaver types of 80 mm block	



Graph .10 New Material Mix Of 25 mm Thickness

COMBINATION XI: Table.19 (C) Combination of new bedding material for load carrying capacity over specific thickness of material .

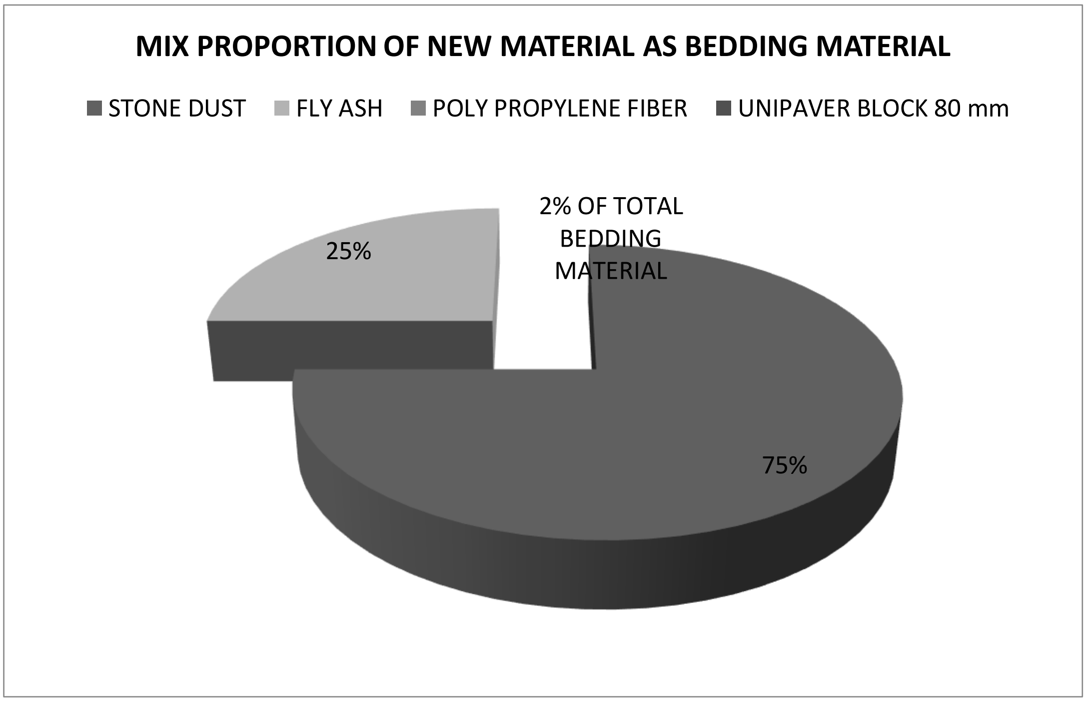
Bedding material types	Thickness of material	Mix proportion	Deflection
Fly ash + stone dust + poly propylene fiber	30mm	25% + 75% with 1% of poly propylene fiber is being mixed by weight of bedding material.	6.1mm
		Unipaver types of 80 mm block	



Graph .11 New Material Mix Of 30 mm Thickness

COMBINATION XII: Table.19 (D) Combination of new bedding material for load carrying capacity over specific thickness of material .

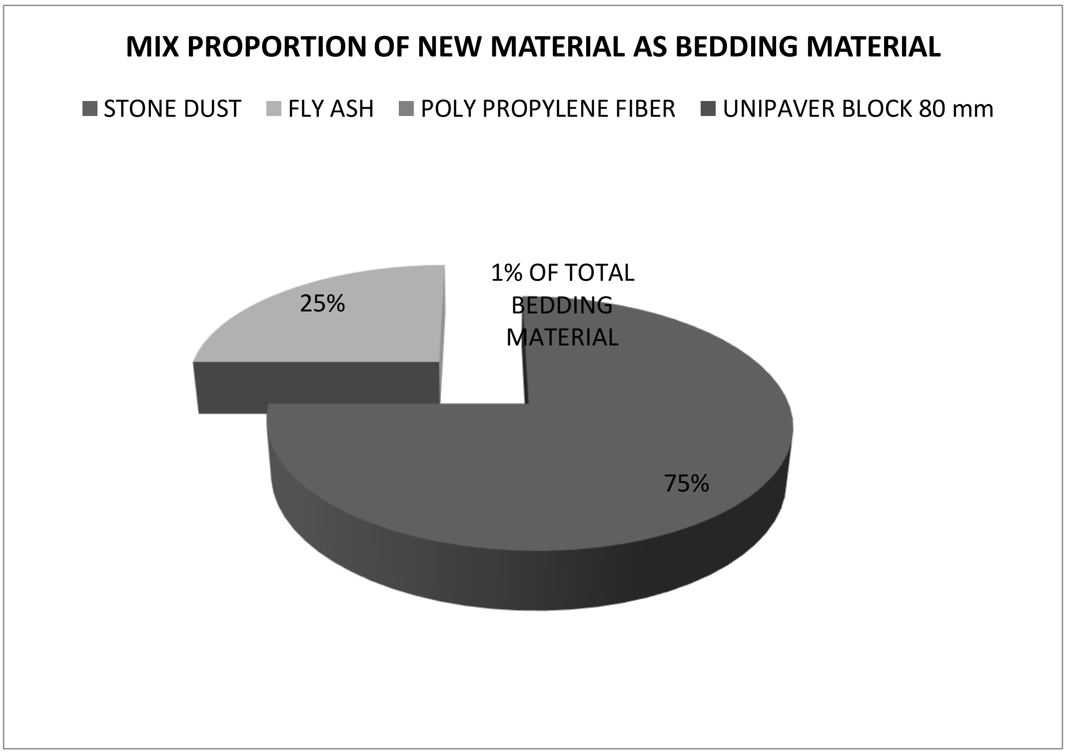
Bedding material types	**Thickness of material**	**Mix proportion**	**Deflection**
Fly ash + stone dust + poly propylene fiber	30mm	25% + 75% with 2% of poly propylene fiber is being mixed by weight of bedding material.	5.8 mm
		Unipaver types of 80 mm block	



Graph .12 New Material Mix Of 30 mm Thickness

COMBINATION XIII: Table.19 (E) Combination of new bedding material for load carrying capacity over specific thickness of material.

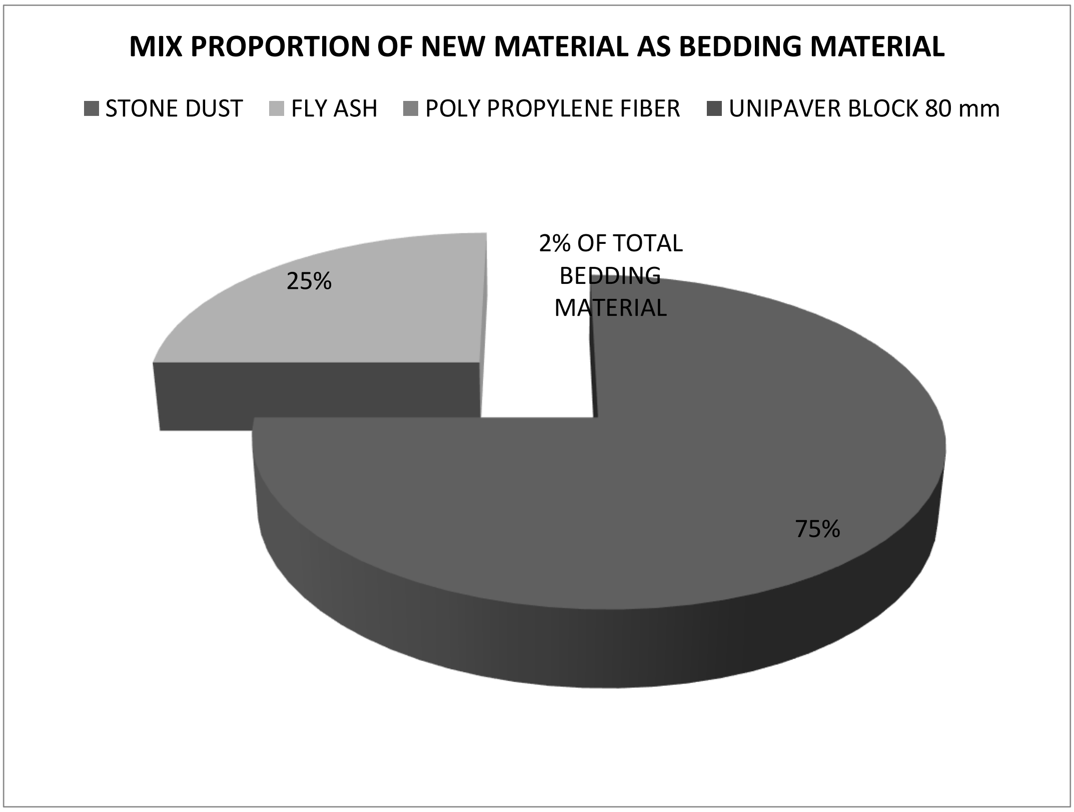
1.Bedding material types	Thickness of material	Mix proportion	Deflection
Fly ash + stone dust + poly propylene fiber	35mm	25% + 75% with 1% of poly propylene fiber is being mixed by weight of bedding material.	5.4 mm
		Unipaver types of 80 mm block	



Graph .13 New Material Mix Of 35 mm Thickness

COMBINATION XIV: Table.19 (F) Combination of new bedding material for load carrying capacity over specific thickness of material.

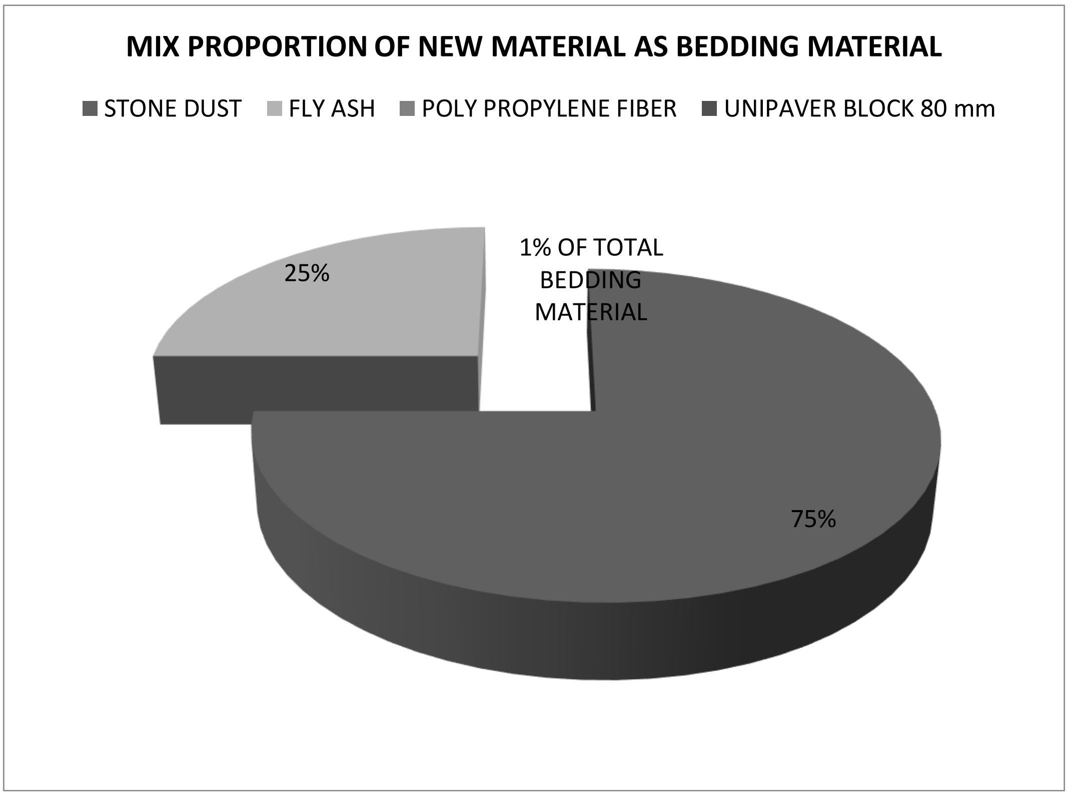
Bedding material types	**Thickness of material**	**Mix proportion**	**Deflection**
Fly ash + stone dust + poly propylene fiber	35mm	25% + 75% with 2% of poly propylene fiber is being mixed by weight of bedding material.	5.1 mm
		Unipaver types of 80 mm block	



Graph .14 New Material Mix Of 35 mm Thickness

COMBINATION XV: Table.19 (G) Combination of new bedding material for load carrying capacity over specific thickness of material

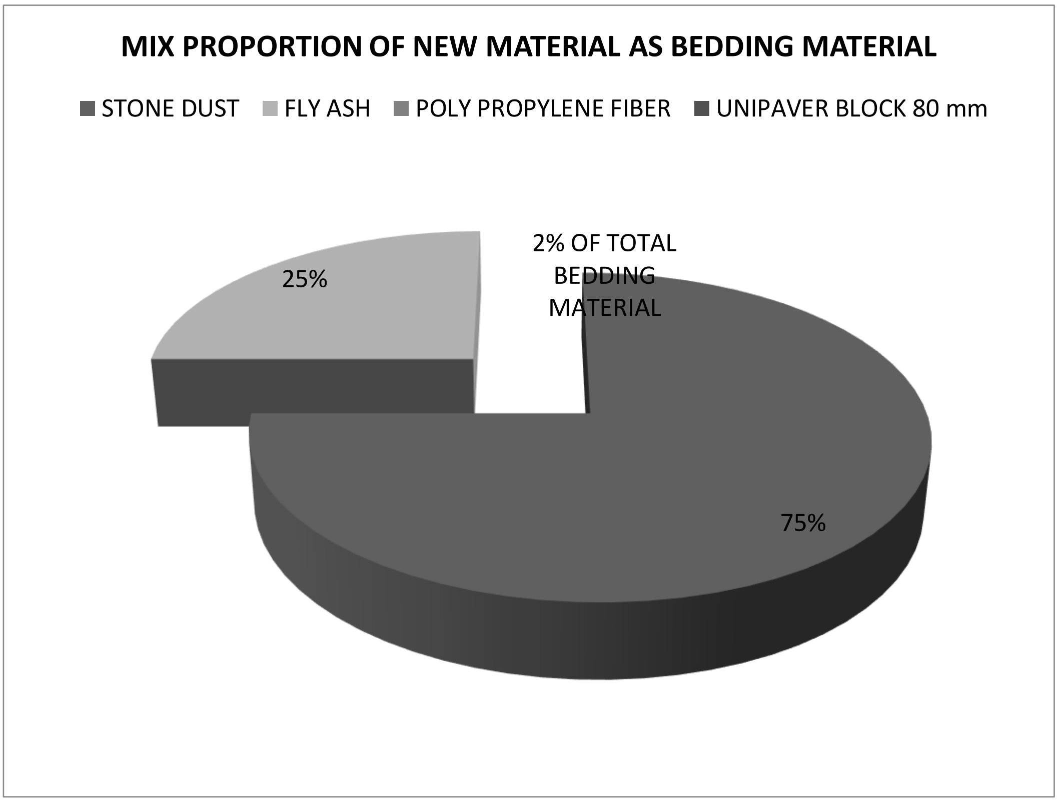
1.Bedding material types	Thickness of material	Mix proportion	Deflection
Fly ash + stone dust + poly propylene fiber	40mm	25% + 75% with 1% of poly propylene fiber is being mixed by weight of bedding material.	4.9 mm
		Unipaver types of 80 mm block	



Graph .15 New Material Mix Of 40 mm Thickness

COMBINATION XVI: Table.19 (H) Combination of new bedding material for load carrying capacity over specific thickness of material

1.Bedding material types	Thickness of material	Mix proportion	Deflection
Fly ash + stone dust + poly propylene fiber	40mm	25% + 75% with 2% of poly propylene fiber is being mixed by weight of bedding material.	4.4 mm
		Unipaver types of 80 mm block	



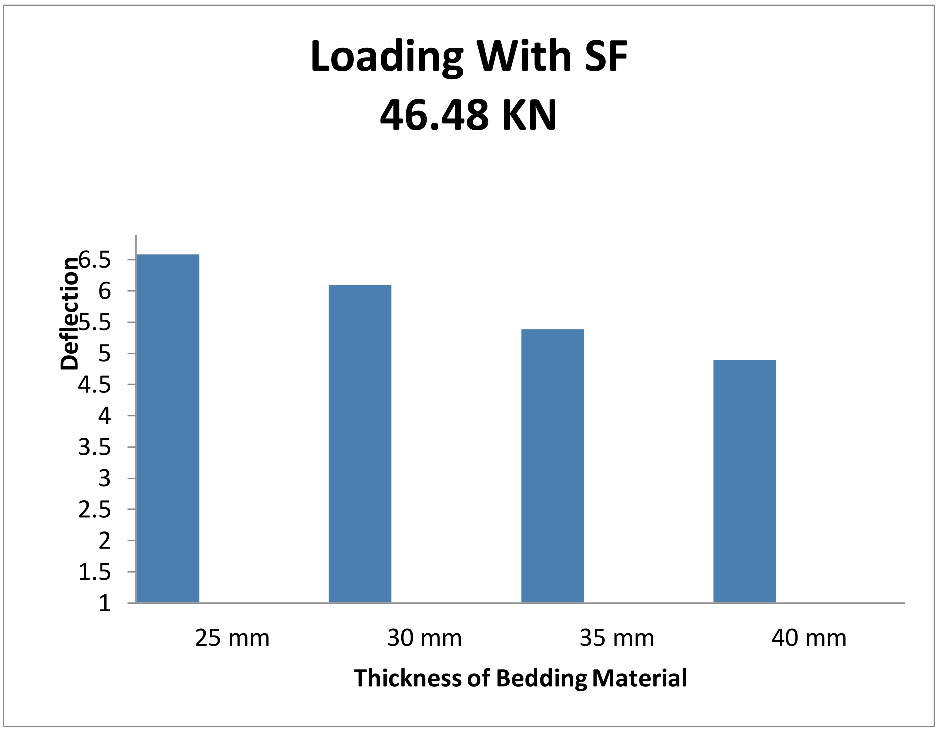
Graph .16 New Material Mix Of 40 mm Thickness

Comparing of all the deflection value which are shown on different thickness after applying calculated loading ,these two combination showing better result for achieving of our objectives.

COMBINATION XVII

Table .20 Unipaver Combination Over New Bedding Material(75:25) with 1 % of poly propylene fiber by total weight of bedding material

BEDDING MATERIAL TYPE	SHAPE OF PAVER BLOCK	THICKNESS OF BEDDING MATERIAL	LOADING WITH SF	SETTLEMENT
stonedust(75%)+ fly ash (25%) with 1% of poly propylene fiber is being mixed by weight of bedding material		25 mm	46.48 KN	6.5 mm
stonedust(75%)+ fly ash (25%) with 1% of poly propylene fiber is being mixed by weight of bedding material		30mm	46.48 KN	6.1 mm
stonedust(75%)+ fly ash (25%) with 1% of poly propylene fiber is being mixed by weight of bedding material		35mm	46.48 KN	5.4 mm
stonedust(75%)+ fly ash (25%) with 1% of poly propylene fiber is being mixed by weight of bedding material		40mm	46.48 KN	4.9 mm



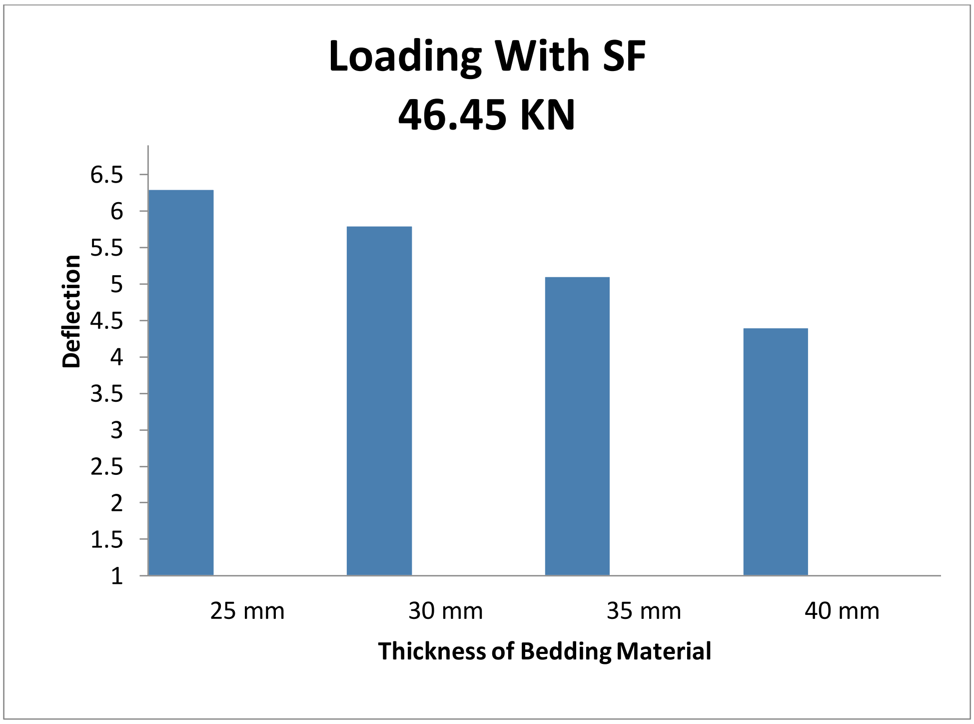
Graph17. Stone dust + fly ash (75:25) with 1 % of poly propylene fiber by total weight of bedding material

COMBINATION XVIII

Table .21 Unipaver Combination Over New Bedding Material(75:25) with 2 % of poly propylene fiber by total weight of bedding material

BEDDING MATERIAL TYPE	SHAPE OF PAVER BLOCK	THICKNESS OF BEDDING MATERIAL	LOADING WITH SF	SETTLEMENT
stone dust(75%)+ fly ash (25%) with 2% of poly propylene fiber is being mixed by weight of bedding material		25 mm	46.48 KN	6.3 mm
stone dust(75%)+ fly ash (25%) with 2% of poly propylene fiber is being mixed by weight of		30mm	46.48 KN	5.8 mm

bedding material				
stone dust(75%)+ fly ash (25%) with 2% of poly propylene fiber is being mixed by weight of bedding material		35mm	46.48 KN	5.1mm
stone dust(75%)+ fly ash (25%) with 2% of poly propylene fiber is being mixed by weight of bedding material		40mm	46.48 KN	4.4 mm



Graph 18. Stone dust + fly ash (75:25) with 2% of poly propylene fiber by total weight of bedding material

Conclusion drawn based on expreimental results while poly propylene fiber is being mixed in stone dust (75%) and fly ash (25%) at rate of 1% and 2% by weight of bedding material

So the conclusion make over above result data that here unipaver block of 80 mm with 35 mm thickness of stone dust and fly ash with 2% of poly propylene fiber of total mixture of bedding material is adopted because the performance or deflection (5.1 mm) found in this combination which is fall with in the recommended range of 25 mm to 40 mm as per IRC SP:63(2004)

From that experimental result which are mixture of stone dust,fly ash and poly propylene fiber ensure our objectives without any more efforts because it reduce excessive deflection will lead to very rapid detoriation of interlocking concrete block pavement leads to shortened service life.

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CHAPTER 5
COST ANALYSIS & COMPARISION

Cost comparison of interlocking concrete block pavement with their different shape with different bedding material for per m^2

Contingency cost: The hidden Value of all known risks is considered by every risk's probability of occurring by the total cost if it appear and then adding up the total cost.

Laying cost: The cost of construction in which labour cost, machinery cost, and other contingency cost are included to calculated total cost of pavement construction.

Cost comparison between different bedding materials of icbp pavement are as-

NATURAL COARSE SAND WITH UNIPAVER (80mm)

S.NO	ICBP PAVEMENT (SHAPE)	QTY	RATE(INR)	AMOUNT (INR)
1	nos. of blocks paver(Zigzag)250×120×80 mm	33	21	33×21= Rs 693
2	quantity of bedding type(Natural sand) 35mm	0.04cum	1250cum	0.04×1250=Rs 50
3	laying cost + contingency	1	95+5	1×100 =Rs100
				TOTAL= Rs 843.00

NATURAL COARSE SAND WITH DUMBLE SHAPE (80mm)

S.NO	ICBP PAVEMENT (SHAPE)	QTY	RATE(INR)	AMOUNT (INR)
1	nos. of blocks paver (Dumble)230×110×80 mm	44	17	44×17=Rs 748
2	quantity of bedding type (LOCAL SAND)35MM	0.04cum	1250cum	0.04×1250= Rs50
3	laying cost + contingency	1	95+5	1×100=100 TOTAL= Rs 834

NATURAL COARSE SAND WITH ROUND DUMBLE SHAPE (80mm)

S.NO	ICBP PAVEMENT (SHAPE)	QTY	RATE(INR)	AMOUNT (INR)
1	nos. of blocks paver (CrossDumble) 50×110×80 mm	34	19	36×19=Rs 684
2	quantity of bedding type(LOCAL SAND)35MM	0.04cum	2800cum	0.04×2800=Rs112
3	layingcost+contingency	1	163.83	1×163.83=163.83
				TOTAL=Rs 921.83

NATURAL COARSE SAND WITH L SHAPE (80mm)

S.NO	ICBP PAVEMENT (SHAPE)	QTY	RATE(INR)	AMOUNT (INR)
1	nos. of blocks paverL-Shape 265×125×80	26	26	26×26=Rs 780
2	quantity of bedding type(LOCAL SAND) 35 mm	0.04cum	1250cum	0.04×1250=Rs50
3	laying cost	1	95+5	1×100=100
				TOTAL= Rs 930

STONE DUST WITH UNIPAVER SHAPE (80mm)

S.NO	ICBP PAVEMENT (SHAPE)	QTY	RATE(INR)	AMOUNT (INR)
1	nos. of blocks paver(ZIGZAG)250×120×80 mm	31	21	33×21= Rs 693
2	quantity of bedding type(STONE DUST))35MM	0.04cum	1412cum	0.04×1412= Rs56
3	laying cost	1	95+5	1×100= Rs100 TOTAL= Rs 849

STONE DUST WITH DUMBLE SHAPE (80mm)

S.NO	ICBP PAVEMENT (SHAPE)	QTY	RATE(INR)	AMOUNT (INR)
1	nos. of blocks paver (DUMBLE)230×110×80mm	44	17	44×17=Rs748
2	quantity of bedding type (STONE DUST))35MM	0.04	1412cum	0.0 4×1412= Rs56
3	laying cost	1	95+5	1×100= Rs100
				TOTAL= Rs 904

STONE DUST WITH ROUND DUMBLE SHAPE (80mm)

S. NO	ICBP PAVEMENT (SHAPE)	QTY	RATE(INR)	AMOUNT (INR)
1	nos. of blocks paver(CROSSDUMBLE)250×110×80mm	34	19	36×19=Rs 684
2	quantity of bedding type(STONE DUST))35MM	0.04	1412cum	0.04×1412=Rs56
3	laying cost	1	95+5	1×100=Rs100
				TOTAL=Rs 840

STONE DUST WITH L-SHAPE (80mm)

S.NO	ICBP PAVEMENT (SHAPE)	QTY	RATE (INR)	AMOUNT (INR)
1	nos. of blocks paver (L-SHAPE)265×125×80	30	26	30×26= Rs 780
2	quantity of bedding type (STONE DUST))35MM	0.04	1412cum	0.04×1000=Rs56
3	laying cost	1	95+5	1×100=Rs100 TOTAL= Rs 936

(STONE DUST + FLY ASH + 2%POLY PROPYLENE FIBER) BEDDING MATERIALWITH UNIPAVER SHAPE (80mm)

S.NO	ICBP PAVEMENT (SHAPE)	QTY	RATE(INR)	AMOUNT (INR)
1	nos. of blocks paver (ZIGZAG)230×114×80mm	33	21	33×21= Rs 693
2	quantity of bedding type (STONE DUST + FLY ASH + 2% POLY PROPYLENE FIBER)35MM	0.03cum+ 0.01cum + 0.0008cum ×900cum =0.72	1412cum 300/Ton 400/kg	0.03×1000= Rs 32 0.3×10kg=Rs 3 0.4×7.2gm= Rs 2.88 B.M = Rs 37.88
3	laying cost	1	95+5	1×100=Rs100 TOTAL=Rs 830.88

(STONE DUST + FLY ASH + POLY PROPYLENE FIBER) BEDDING MATERIALWITH UNIPAVER SHAPE (80mm)

S.NO	ICBP PAVEMENT (SHAPE)	QTY	RATE (INR)	AMOUNT (INR)
1	nos. of blocks paver UNIPAVER 230×114×80mm	33	21	33×21=693
2	quantity of bedding type (STONE DUST + 2%FLY ASH + POLY PROPYLENE FIBER) 40MM	0.03375 +0.011cum + 0.0008cum	1412cum 300 400/kg	0.620×700=Rs47.65 3×11.26kg= Rs 3.40 0.4×8.1gm= Rs3.24 B.M = Rs 54.29
3	laying cost	1	95+5	1×100=Rs100 TOTAL=Rs 847.29

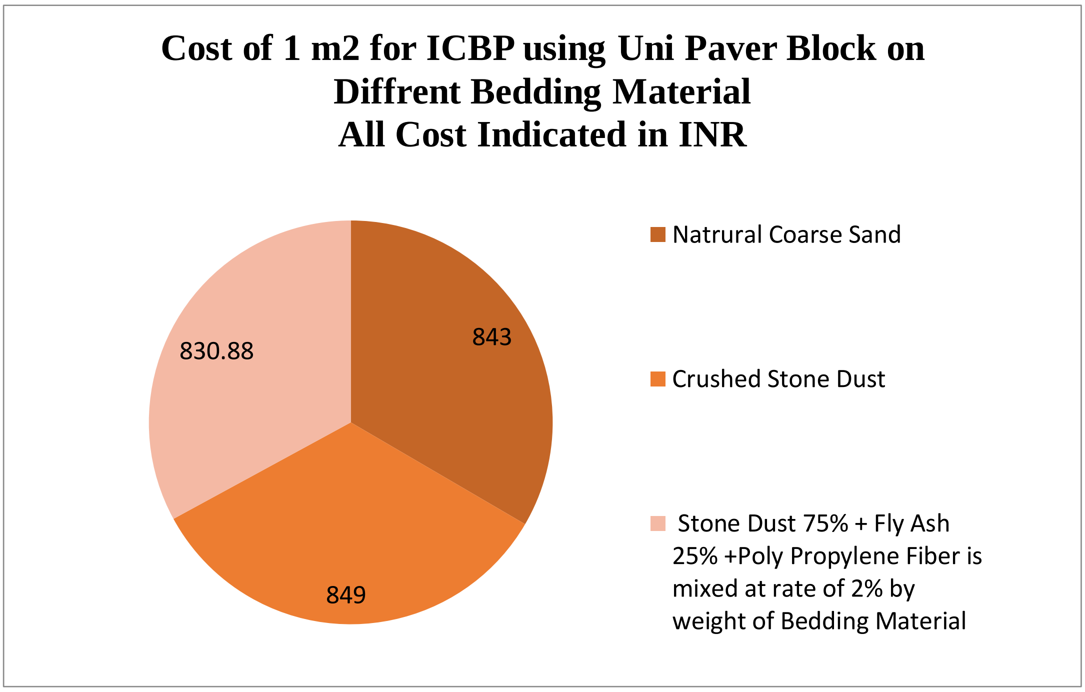
Estimation of cost of interlocking concrete block pavement (stone dust + fly ash +2% poly propylene fiber) bedding material with unipaver shape (80mm) and asphalt pavement for the area of 1 m2.

S.NO	ICBP PAVEMENT	QTY	RATE(INR)	AMOUNT (INR)
1	**Nos.of unipavers size=230×114×80**	**33**	**21**	**33×21=Rs 693**
2	**laying cost + bedding material**	**1**	**37.88+100**	**Rs 137.88**
				Total= Rs830.88/ m^2

S.NO	ASPHALT PAVEMENT	QTY(lit)	RATE(INR)	AMOUNT(INR)
1	**bituminous grade 60/70** **VG-30 (iocl)**	**2.5**	**65**	**2.5×65=162.5**
2	**construction cost** **i-labour costii-mechanical equipments roller etc** **iii-fuels cost**	**1**	**300**	**1×300= Rs300** **1x195**
				Total=Rs657.50 /sq m

Cost comparison of interlocking concrete block pavement (stone dust + fly ash + poly propylene fiber) bedding material with unipaver shape (80mm) and asphalt pavement are as-

INTERLOCKING CONCRETE BLOCK PAVEMENT	ASPHALT PAVEMENT
Cost of pavers = Rs17 **to** Rs26	**cost of asphalt** per **liter = Rs 65**
laying cost= Rs100/m^2	**construction cost=** Rs 300/m^2
Design life=20Yrs	**Design life=**15 **years**
maintenace cost =0 for initial 5 years	**maintenance cost =15 % of cost of construction after each 3 years.**



Graph.19 Cost comparison of unipaver block with different bedding material

Conclusion drawn based on study

On the basis of these eastimation, cost of interlocking concrete block pavement **Rs830.88/m^2** while cost of Aasphalt pavement **Rs657.50/m**^{2}, the icbp pavement (stone dust + fly ash + poly propylene fiber) bedding material with unipaver shape (80mm)

are 26% costly than asphalt pavement for initial cost of construction of the pavement. But for long term analysis icbp pavement are very cost effective alternative due to thier less maintenance cost and having a good salvage value (10% to 15 % of total construction cost).The complexity of the pattern and the edge has an effect on the price as well. Rs 8- Rs10 per sq. foot around here, so 1 sq. meter Rs90 – Rs150 in INR. amount can be increase or decrease. It gets cheaper as the different quantity and quality concerned with contractor.

After analysis of these cost comparision of entire shape and its bedding material type it is observed that (stone dust + fly ash + poly propylene fiber) bedding material(35mm) with unipaver shape (80mm) are strong enough for using as heavy trafficing pavement as arterial road and city street in lucknow city as well as cost effective and required less number of block paver as compare to other pavers shape with same properties.

CHAPTER 6
CONCLUSION

Based on all experimental work following conclusion are being made:

1. Unipaver Block with 35mm bedding thickness is found to be best having 5.1 mm deflection over bedding material of Poly propylene reinforcement fiber is being mixed in stone dust (75%) and fly ash (25%) at the rate of (2%) by weight of bedding material.

2. The combination of unipaver block with addition of 2% of poly propylene fiber by weight of bedding material as stone dust 75% and fly ash 25% of fly ash, gives more benefit as reduce settlement from that maintenance cost will also reduced and lengthen service life were achieved as compare to other types of bedding and block combination.

3. Performance of all paver block combination are found better over stone dust and mixture of stone dust and fly ash with fiber reinforcement proportion as compare to natural coarse sand.

4. Cost of fiber reinforcement mix bedding material of thickness 35mm combination with unipaver blocks is average 2.25% lower than stone dust bedding material and 1.55% lower than natural coarse sand bedding material.

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Scope for Future study

Following points were need to be checked

1. Full scale field test.

2. Low cost fiber from which cost can be minimised during construction.

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