**A Thesis on**

# CONSTRUCTION OF LOW COST RIGID PAVEMENT BY USING ALTERNATIVE MATERIAL

Submitted for partial fulfillment of award of

**MASTER OF TECHNOLOGY**
Degree in

## Constructional Technology and Management

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# DECLARATION

I declare that the research thesis entitled "**Construction Of Low Cost Rigid Pavement By Using Alternative Material**" is the bonafide research work carried out by me, under the guidance of **Mr. Mohd Sadat,** Assistant 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 diplomas, and has not been submitted anywhere else.

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# CERTIFICATE

Certified that the thesis entitled **"Construction Of Low Cost Rigid Pavement By Using Alternative Material"** is being submitted by **Mr. KAHLID MASOOD (1801103004)** in partial fulfillment of the requirement for the award of degree of Master of Technology (Constructional Technology and Management) of Integral University, Lucknow, is a record of candidate's own work carried out by him 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.

**Mohd Sadat**
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**KHALID MASOOD**
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PQC: Pavement Quality concrete

DLC: Dry Lean Concrete

GGBS: Ground granulated Blast Furnace

IRC: Indian Road Congress

CBR: California Bearing Ratio

GSB: Granular Sub Base

Fck: Characteristic Compressive Strength

F'ck: Target mean Strength

C.A. Coarse Aggregate

F.A.: Fine Aggregate

OGL: Original Ground level

$\sigma$ : Standard deviation of field test samples, Mpa

OMC: Optimum Moisture Content

$P_{ptb}$ : Paramemter of the bar (mm)

$N_c$: Number of longitudinal Joints

n: Design Periods (Years)

MEPDG: Mechanistic Empirical Pavement Design Guide

LTE: Load transfer Efficiency

L: Leangth of the bar

$L_d$ : Distance between free transverse Joints

$F_c$ : Pound per cubic Inch

R: Flexural Stifness, MNm

S: Flexural Stress in Slab, MPa

U: Poisson's ratio of concrete

Y: Unit weight of concrete

$W_c$ : Length of the transverse Joints

CVPD: Commercial Vehicle per day

Acs: Cross-section area of one tie bar, $mm^2$

B: Lane width,m

bd: Dowel Diameters, mm

Cs: Spacing of transverse joints

OPC: ordinary Portland cement

RSA: rice straw ash

N.H.: National highway

S.H.: State highway

# INTRODUCTION

## 1.1 General

Pavement A road surface or pavement is the durable surface material laid down on an area intended to sustain vehicular or foot traffic Such as road or walkway.

**Type of pavement**

There are two type of pavement mostly

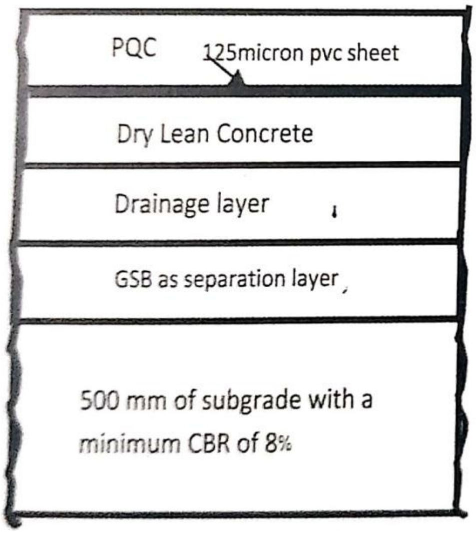
- Flexible pavement
- Rigid pavement

**Flexible pavement**

It is generally a bituminous pavement where bituminous surface course laid over base course and sub base course and it consist of series of layer with the highest quality of materials at or near the surface of pavement. It reflects the deformation of sub grade and subsequent layers on the surface. The aggregate interlock, particle friction and cohesion define its stability and sub grade strength greatly influenced the pavement design. The load is transferred through the component layer. Temperature variation due to change in atmospheric condition do not produces stresses in flexible pavement. Flexible pavement has self healing properties due to heavier wheel load are recoverable due to some extent. To design the flexible pavement we use IRC 037. As we know bitumen is extracted from crude oil and India imports 80% of crude oil from foreign country so government is focusing on other type of road pavement.

**Rigid pavement**

For designing rigid pavement we require IRC 58 code. Portland cement concrete is used as primary structural element for rigid pavement. The reinforcement is provided depending upon the soil strength and loading capacity. Prestressed concrete slab can also be used as surface course. The concrete slab usually lies on the compacted granular or treated sub base, which is supported, in turn, by a compacted sub grade. The strength of rigid pavement mostly depends upon the concrete slab, while bottom layer are constructed using low cost materials to make it economical. Due to rigidity and high tensile strength, a rigid pavement tends to distribute the load over a relative wide area of sub grade and the major portion of structural capacity is supplied by the slab itself. Due to increase demand and decrease in availability of aggregates for production of concrete in road construction there is need of identifying a new source of aggregates from recycled waste materials. So we need some alternative materials.



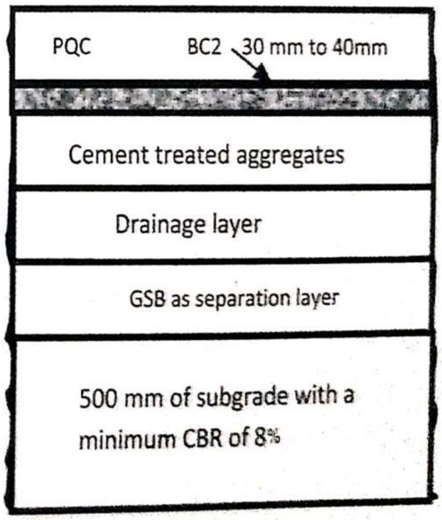




**Fig 1.1: Typical Cross Section of Concrete Pavement**

### 1.2 Use of Alternative Materials in Rigid Pavement

Alternative construction material in the construction of low cost rigid pavement is now used in the broad manner as it has low maintenance and operating cost is low. It also used in energy efficiency and enhances indoor environment quality and also it reduces strain on local resources.As we know conventional material such as Bitumen, crushed aggregates are their but the process of producing of producing aggregates materials causing extreme disruption to the Environment.So as the evaluation of the road industry is growing there are several waste by-products and material have been evaluated for utilization and practiced in the field. There are several recycled product has been used in the field. But laboratory experiment and field observation which has turned out to be further in the depth study.Reclaimed asphalt pavement, plastic waste, mine waste, recycled crushed glass, fly ash, pond ash, oil shale sand are long in the list. These products used in the field will help in preserving natural and precious resources. Therefore, practice by the industry and educating will develop a better recycled material in the road industry. The most dominant recycling material are in practice at present include plastic waste, bottom and fly ash, oil sand, marble dust.

## 1.3 Development of alternative materials

- Quality of good aggregates are depleting and increase in the cost of materials extraction, research is been done for suitable alternative materials.
- Test and specification of conventional material is inappropriate for evaluation of non-conventional material.
- The particle size, grading and chemical structure may differ substantially from conventional materials.
- For the use of alternative material is been devised and new acceptable criteria are to be formed
- However with the notable performance based test, the performance of the conventional as well as new materials can be tested on same set up and be compared.

## 1.4 Industrial and domestic wastes

- Industrial and domestic waste product provides a prospective source of alternative materials.
- These materials are cheaply available.
- Also, their use in road construction provides an efficient solution to the associated problem of pollution and disposal of this waste.
- The rigid pavement have benefits in high inclination and heavy track circulation and where climate is very hot so low cost alternatives would make the use of concrete pavement more favorable.

# OBJECTIVE

The first objective is to establish intermediate goals that will serve as stepping-stones to the ultimate goal of providing high-quality, cost-effective concrete pavement for future generation. List of goals that would provide the greatest contribution to the design of low cost concrete pavement

**Objective for Low Cost Concrete Pavement**

- Design of cement concrete pavement using low cost materials as per IRC 58 – 2015 recommendation
- Reduce the time required for construction, rehabilitation and reconstruction
- Improve the performance of recycled materials used for construction concrete pavement
- Improve and quantify the quality control/assurance processes for concrete pavement construction and rehabilitation
- Implement tools and methodologies necessary for making more cost effective decision
- Determine what waste materials have been successfully used in other states and what applications have been proven effective in highway construction;
- To reduce the cost by the replacement of cement by usually cheaper alternatives binder and the use of steel slag increase mechanical property.
- This study also aim to reduce the pollution and disposal the use of industrial and domestic waste are done.

# SCOPE AND LIMITATION

- The use of materials to be replaced by natural sand will give new dimension in concrete mix design and it will revolutionize the construction industry
- By products such as discarded tires, plastics, glass, burnt foundry sand has provided specific effect on the property of fresh and hardened concrete. The used of waste product in concrete make it economical.
- The development of new construction materials using recycled plastic is important to both the construction industries and the plastic recycling industry.
- Innovation of alternatives materials can give advantage of quality and economy, environmental sustainability.
- Allocation of environment impact is necessary by avoiding waste treatment from disposing the byproducts.
- With the natural sand deposits the world over drying up, there is acute need for a product that matches the property of natural sand in concrete.

# METHODOLOGY

**Designing of rigid pavement is done and the quantity of material is to be found out and the cost of materials used in the rigid pavement**

⇓

**The trail mixes is done as per IRC10262:2009 to find out the compressive strength of PQC and DLC as per requirement with the help of code book generally IRC: 58-2015 is used**

⇓

**We will use alternative waste material which will partially or fully replace the cement, sand fine aggregate**

⇓

**We will compare the compressive strength, flexural strength, workability when the conventional material such as cement, sand fine aggregates is replaced with alternative materials is such as GGBS, silica fume, ceramic waste copper slag and replacement is done with the help of code book**

⇓

**When the compare the compressive strength and flexural strength is found out with using alternative materials and it fully satisfied the given condition the rate is compared when is used of alternative material and when alternative material is not used.**

⇓

**As we know the most costly material used in PQC and DLC is cement and if we found out some cheap alternative material which has some property as cement then we can easily reduce the price of construction of 1 cubic meter of rigid pavement**

⇓

**With using of alternative materials we can easily reduce the cost of rigid pavement without comprising the compressive strength and flexural strength**

# LITERATURE REVIEW

**P GOPAL AND G MANOHAR REDDY[2017]** Found out that ground granulated blast furnace slag is waste material and keeps the bond , vitality, cost, natural and socio-monetary favorable circumstances and can be presented in bond concrete as a fraction option of concrete, and without trading off its quality and toughness. GGBS is waste item from the iron assembling undertaking which could likewise utilize as fraction substitute of bond in cement and GGBS has solidifying properties. GGBS is eco accommodating substitute slag and reduce the cost also.

Rigid pavement in India is greatly encouraged as it fulfills two of the greatly requested necessities of asphalt texture in India, economic and brought down. Now we know that natural materials to form concrete are diminishing so some of the non recyclable substance is utilize as a part of solid blend fractional supplanted GGBS is made from the impact heater used to make press. If we GGBS replace some cement and form Portland concrete it will immediately decrease the $CO_2$ emission at greater extent. GGBS substitution can be eco accommodating substitute slag and can reduce the cost also.

**Proposed Method**

The review entitled" A test think about on quality on attribute of cement in inflexible asphalts by fraction supplanting of bond with GGBS" An examination of constrain attribute of cement is done by method for taking after the procedure given underneath.

M20 Traditional control blend is set up with consolidate extent is 1:1.52:3.02.

Now supplanting with GGBS 10% 20% 30% 40% in every single set up shape, barrels, shaft and also these are cured in 7, 14, 28 days to find out compressive quality, split rigidity and flexural quality for these individuals day.

- MIX DESIGN:- They have done as per IS:10262-1982 but now we are using as per IS:10262-2009.
- BATCHING
- MIXING

- CASTING OF MOULD
- COMPACTION
- CURING
- TESTING:- Compressive strength, split tensile test, flexural test, tensile test.

They experimental result there upon the increase in GGBS replacement level the degree of workability of concrete increased. It suitable for rigid pavement.

- GGBS:-3-4 rs/kg
- Cement(OPC 43 GRADE):-8 rs/kg

**Compressive Strength Test**

Cube size is off 15cm×15cm×15cm and filling should be done in three part with 35 stoke at each layer and the rod size is 16mm and 600mm length oiling should be done inside the cube then after filling is done cube should left for 24 hour and when cube is taken out from the mould it should be placed with wet cloth to maintain temperature 27 to 30˚C before curing now cube should be immersed in to water and the temperature should 27 to 30˚C

Now for testing we will use compression testing machine before placing the cube between the plate cube should be clean, placed properly and load of 140 kg/mm2 is applied and the load at which cube form crack is noted down and compressive strength is found out by dividing load by its area.

**Fig 5.1 Compressive strength testing machine**

**Flexural Strength Of Concrete**

Concrete as we know is relatively strong in compression and weak in tension. In reinforced concrete members, little dependence is placed on the tensile strength of concrete since steel reinforcing bars are provided to resist all tensile forces. However, tensile stresses are likely to develop in concrete due to drying shrinkage, rusting of steel reinforcement, temperature gradient and many other reasons. Therefore, the knowledge of tensile strength of concrete is of importance.A concrete road slab is called upon to resist tensile stresses from two principal sources wheel load and volume change in the concrete. Wheel load may cause high tensile stresses due to bending, when there is an inadequate sub grade support. Volume changes, resulting from changes in temperature and moisture, may produce tensile stresses, due to warping and due to the movement of the slab along the sub grade.Stresses due to volume changes along may be high. The longitudinal tensile stress in the bottom of the pavement, caused by restraint and temperature warping, frequently amounts to much as 2.5 Mpa at certain periods of the year and the corresponding stress in the transverse direction is approximately 0.9 Mpa. These stresses are additive to those produce by wheel loads on unsupported portions of the slab.

**Fig 5.2Flexural testing of concrete beam mould**

**BRIND KUMAR AND ARUNABH PANDEY [2014]:-**They have found out that OPC is conventionally used for concrete pavement and it is used to emit the gases responsible for green house gases and every 1000 kg of cement liberates about 814-935kg of $CO_2$ so they use rice straw ash which is residue left after burning rice paddy and it has a potential to replace OPC as mineral admixture and this paper shows that utilization of rice straw ash in palace of OPC partially to economize the PQC. Pozzolans rice straw ash can be study and most of them can be studied for use in general purpose concrete (less then M25 GRADE) El-sayed et.al.(2006) that rice straw satisfy the requirement of ASTM class N, F, C pozzolan and has specific gravity 2.25 and specific area 18460cm2/gm.

According to Rana singhe(1993)

**Table 5.1: Comparison between OPC, RSA, MICROSILICA**

| | OPC | RSA | MICROSILICA |
|---|---|---|---|
| SILICA CONTENT% | 22 | 82 | 94 |
| SPECIFIC SURFACE AREA cm2/g | 3000 | 18460 | 20000 |
| SPECIFIC GRAVITY | 3.14 | 2.25 | 2.20 |
| COST RS/KG | 6 | FREE | 14 |

**Table 5.2: CHEMICAL COMPOSITION OF RSA:-**

| | |
|---|---|
| SIO2 | 65.92 |
| AL2O3 | 1.78 |
| FE2O3 | 3.02 |
| CAO | 2.4 |
| MG2O3 | 3.11 |
| SO3 | 0.69 |
| LOSS OF IGNITION | 9.71 |

**FRANK COLLINS AND J.G.SANJAYAN [1998]:-**They found out the result after investigation into the effect of ultra fine materials on workability and strength development of concrete containing alkali-activated slag as the binder and found that workability improves after partial replacement of slag with ultra fine fly ash but strength development is similar as OPC. Partial replacement of slag with condensed silica fume and ultra fine slag show the greater strength than AAS at ages greater than one day but it has a disadvantage AAF/CFS has higher water demand where AAF/UFS has minimal loss of workability compared AAS. Partial replacement of OPC with UFS with blain fineness 800-1500 m2/kg and concrete strength enhanced by[3,4] with workability improvement and using fly ash mechanically processed to less than 5µm particles size shows improve concrete strength while maintaining workability.

**ROY AND SILSBEE [13]:-**Report high early and later strength of AAS paste containing less than 4% CSF addition.

**DOUGLAS AND BRANDSTETR [14]:-** Report slightly greater compressive strength of mortar containing 8% CSF compared with identical mortar containing 5% fly ash of normal fineness.

AAS/CSF concrete achieve the highest strength development over 91 days of curing and use of super plasticizer may overcome its workability than AAS concerete

**Ramakrishnan. S, Velraj Kumar. G et.al [2014]** experimentally investigated on the replacement of cement partially with rice husk ash in proportions of (0, 5, 10, 15, 20, 25%) for M40 grade of concrete. the variations in various strength parameters for the replacements are studied. The authors stated that there is a reduction in compressive, flexural and tensile strengths with increase in rice husk ash addition, the porosity and impact strength also decreased with increase in rice husk ash addition above 10% hence it is concluded that a replacement of 5-10% is optimum.

**Rena N Shukla [2016]** investigated on the replacement of natural 20mm coarse aggregate with steel slag aggregate and cement with fly ash for M30 grade of concrete , mixes were prepared for various replacements of them with fly ash ranging from 0-25% in increments of 5% and steel slag ranging from 0-50% in increments of 10% and the author made the following conclusions, addition of steel slag and fly ash improved the properties of concrete and optimum results are attained at (15%fly ash+ 30% steel slag ) replacement.

**Krishna Moorthy and R. Ashwini [2015]** studied on properties of M30 grade of concrete in which cement is partially replaced by G.G.B.S(Ground granulated blast furnace slag) in increments of 10% up to 50% and fine aggregate is fully replaced by quarry dust and concluded that at 50% replacement of G.G.B.S the mix attained maximum compressive strength and corrosion resistance.

**Manthena Srilakshmi [2013]** investigated on tile dust as a replacement to cement for M30, grade of cement in increasing proportions of 10% up to 50% and the development of compressive flexural and split tensile strengths of samples were observed for 7,28 and56 days. The authors concluded from their study that optimum results are attained between 10-20% replacement and replacement can be done up to 30% feasibly without much loss in strength characteristic.

**K. Perumaland and R. Sundara Rajan [2004]** investigated on effects of partial replacement of silica fume with cement in high performance cement of grades M60, M70 and M110. The replacements of silica fume was done in proportions of (0, 2.5, 5, 7.5, 10, 12.5 and 15%) by weight of cement respectively and concluded that 10% replacement showed optimum results for all high performance mixes. Samples with silica fume replacement also showed high acid resistance, sea water resistance, abrasion resistance and impact resistance thereby improving durability of mixes.

**Fernando pelisse et.al.[2011]** :-Effect of alkaline activation and silica fume addition. Concrete formulation were produce with the replacement of 10% of sand aggregates by recycled tire rubber using convention rubber and rubber modified with alkaline activation and silica fume addition to improve mechanical properties. The water cement ratio and the testing age were used as addition variable. The concrete characterization was performed by testing compressive strength, elastic modulus, density and microstructure. The recycled tire rubber proved to be excellent aggregates to use in concrete. It was observed that its compressive strength was reduced to only 14%(28 days), in comparison to the convention concrete, reducing 48 MPA for the mixture with higher resistance and the concrete composition is found lighter.

**Kumar and Dhaka (2016)** :- Done a study on partial replacement of cement with silica fume recommended in IS : 15388 – 2003, IS : 456 – 2000, IRC : SP : 76 and IRC : 44- 2008 that we can use silica fume as admixture with proportion of 3 to 10% of cement. So they noted the effects on concrete properties for M35 concrete mix with varying percentage level of silica fume is 5, 9, 12 and 15% by weight of cement. The optimum percentage replacement of SF was found out to be 12% for which maximum compressive strength was obtained. The maximum compressive strength for 7 and 28 days was found out as 30.95 N/mm2 and 46.14 N /mm2.

**Fatima et.al. (2013):-** They have found out by experiment that ceramic dust which produced by waste of bricks, roof, floor tiles and stoneware waste industry. Concrete (M35) was made by replacing up to 30% of cement (OPC 53) grade with ceramic dust (passing 75 µm) shows good workability, compressive strength, split-tensile strength, flexural strength and elastic modulus. In this experimental investigation, concrete specimen was tested at different age for different mechanical properties. The result shows that with water cement ratio 0.46, core compressive strength increased by 3.9% to 5.6% by replacing 20% of cement content with ceramic dust. It was observed that no significant change in flexural strength and split tensile strength when compared to conventional concrete.

Ceramic waste is generally of two types, waste earthenware and also cracked during manufacturing process and possesses pozzolonic properties. Ceramic waste as a replacement of natural aggregate in concrete slab shows good abrasion resistance and tensile strength with confirmative of relevant standard. Ceramic waste are used in road sub-base layer as filler and in PQC reached strength 40 –50 Mpa and also replace fine aggregate and found good compressive strength. Researchers found that the use of ceramic waste more than 20% can reduce the compressive strength.

Uses of three materials were taken ceramic waste, aggregate and cement to prepare sample. In this research ceramic waste is taken from morbi ceramic industrial area, Rajkot and specific gravity is found out to be 2.717 and 98.5% of ceramic dust passes through sieve of 0.075mm.

**Table 5.3: Chemical Properties of Ceramic Dust**

| S.NO. | Test description | Result |
|---|---|---|
| 1 | Aluminium oxide | 32.43% |
| 2 | Calcium oxide | 2.16% |
| 3 | Ferric oxide | 1.152% |
| 4 | Magnesium oxide | 0.251% |
| 5 | Potassium oxide | 0.009% |
| 6 | Silicon oxide | 60.21% |
| 7 | Sodium oxide | 0.093% |

Other ingredient consist of OPC 53 grade cement confirming to IS 12269 – 1987 and fine aggregate of specific gravity 2.66 and fineness modulus 2.65 confirming to IS 383 – 1970 was used along with coarse aggregate. The physical properties of coarse aggregate such as aggregate impact test, Los Angeles test, water absorption test etc.

Proportion to find out compressive strength by conducting several trail mix and proportion of these mixes were used to find out an optimum mix proportion. The different water content ratios (0.40, 0.42, 0.44, 0.46, 0.48 and 0.50) were used with respective w/c ratio

**Table 5.4: Proportion for Compressive Strength**

| Ingredient | % ceramic waste dust | | | |
|---|---|---|---|---|
| | 0 | 10 | 20 | 30 |
| Cement (kg) | 9.88 | 8.89 | 7.9 | 6.92 |
| Ceramic waste (kg) | 0 | 0.90 | 1.58 | 2.08 |
| Water (litre) | 4.45 | 4.45 | 4.45 | 4.45 |
| Sand (kg) | 19.05 | 18.91 | 18.77 | 18.63 |
| Coarse aggregate 10mm | 8.89 | 8.82 | 8.76 | 8.69 |
| Coarse aggregate 20mm | 22.86 | 22.69 | 22.52 | 22.36 |
| Admixture (gms) (sika LT 10) | 25 | 27 | 28 | 28 |
| No of cubes | 18 | 18 | 18 | 18 |

**Vinod kumar (2012):-** Found experimentally of using copper slag, by – product of copper refineries, as a partial replacement of sand making of pavement quality concrete and dry lean concrete mixes. The physical properties of copper slag are similar to those of natural sand. For many year, research in the field of concrete technology has concentrated on seeking alternative inexpensive materials to be used as partial or full replacement of conventional constituent of concrete. Copper slag as a waste can be used as partial replacement of fine aggregate in concrete mixtures.

A control mix for PQC was prepared with 400kg/m3 of OPC and W/C ratio of 0.40 other concrete mixtures were then prepared by substituting 20%, 40%, 60%, 80% copper slag in control mixes. Compressive strength, flexural strength at 7 and 28 days and DLC is designed with 150 kg/m3 of OPC and then replacement is done with 20%, 40%, 60%, 80% copper slag as fine aggregate. DLC mixes were then prepared with different water content with view to find out the optimum water content for achieving maximum density. The laboratory test result shows that the compressive strength of PQC 7 and 28 days was not affected by inclusion of any content of copper slag as fine aggregate in concrete mixture small gradual increase in flexural strength at 28 days was observed with an increase in copper slag content and experimentally found that copper slag can be used both in PQC and DLC mixes as partial replacement of fine aggregates upto to the level of 40%.

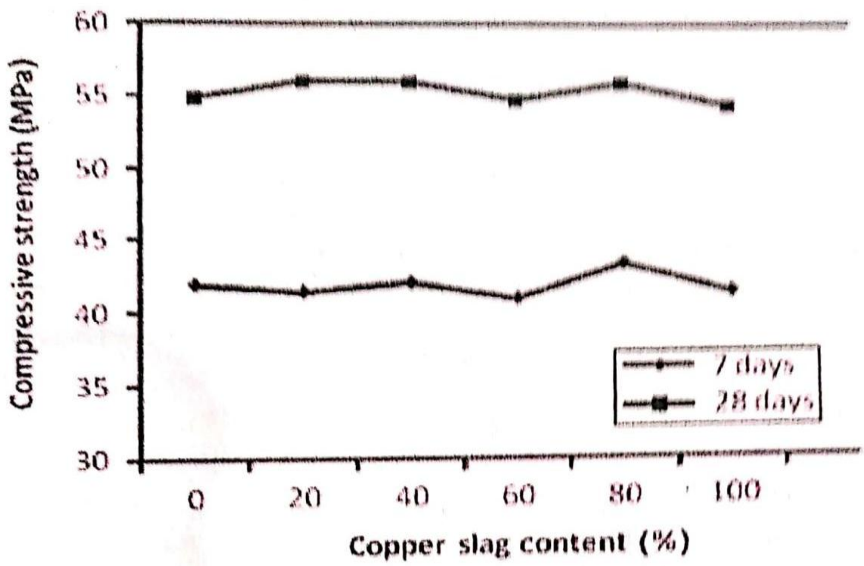



**Fig 5.3 Compressive Strength versus copper slag content**

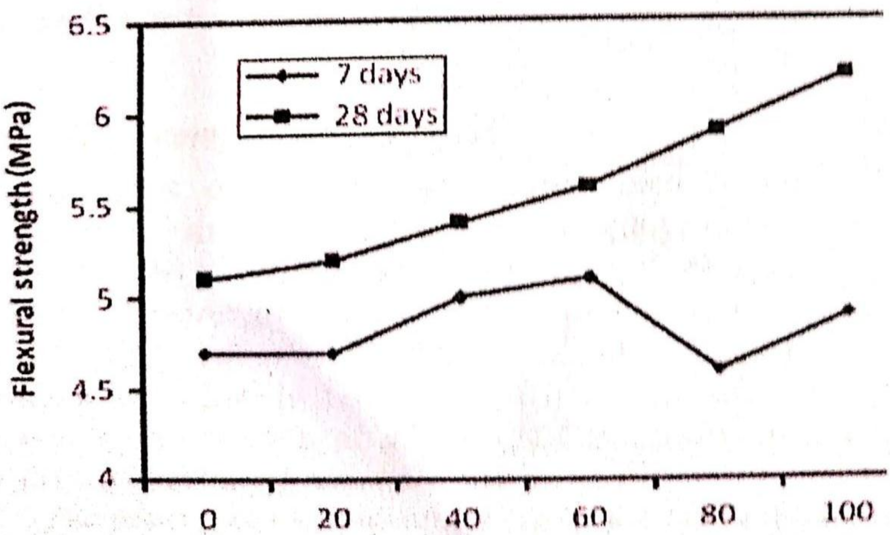



**Fig 5.4 Copper slag content (%)**

# DETAIL ABOUT RIGID PAVEMENT

## 6.1 FACTOR IN THE DESIGN OF RIGID PAVEMENT

- The thickness is the most important factor that is design as per requirement
- The warping stress is due to the variation in the temperature of pavement depends on length and width.
- The load carrying capacity is mainly depends due to the rigidity and high modulus of elasticity of the slab.

## 6.2 DIFFERENT LAYERS AND THE USE OF MATERIALS

- **SUB GRADE SOIL:-** The sub grade is nothing but the existing soil layer which is compacted using equipment to provide stable platform for rigid pavement. The sub grade soils are subjected lower stresses than the top layer since the stresses will reduce with depth. Sub grade soil may vary considerably. The stresses coming from the top layer is received by different soils in different manner. Some soil may resist them and some may not. It is depends upon the interrelationship of texture, density, moisture
- content and strength of sub grade. So, proper examination should be done on sub grade before construction. At the same time the pavement layers above the sub grade should be capable of reducing stresses imposed on the sub grade soil to prevent the displacement of sub grade soil layers.
- **FROST PROTECTION LAYER:-** In low temperature region there is problem of frost action on the pavement. If the soil contain high ground water table, during low temperature the water will freeze and frost heave will form under the sub grade which will cause the pavement to rise because of non uniform of ice crystal. Similarly when the ice melt the pavement will penetrate into the sub grade when load comes on it. To overcome this frost protection layer should be provided. Generally good base course and sub base course themselves act as the frost protection layer.
- **GRANULAR SUB BASE OR STABILIZED SUB BASE COURSE:-**It is the third

layer from the top and is in contact with sub grade soil and base course. It is constructed by using low quality aggregate than the base course but they should be better quality than sub grade. Generally sub base course is not required when the traffic loading is light. When the loading exceeds 100000 pounds it should be constructed. Its primary function is to provide support for the top layers and it also serves as frost action controller and prevents the intrusion of fines from sub grade to top layer. The drainage facility will also improve when there is a sub base course.

- **GRANULAR BASE:-** The base course or granular base is the second layer from the top and constructed using crushed aggregates. The course helps the surface course to take additional load. It provide stable platform to construct rigid pavement. It is also useful to provide sub surface drainage system. The frost action can be controlled by the stabilized base course. It helps to control swelling of sub grade soil. The base course thickness should be minimum 100mm.

- **CONCRETE SLAB:-** The concrete slab is the top most layer which direct contract with vehicular loads. This is also called surface course. It is water resistance and prevents the water infiltration into base course. It offer friction to the vehicle to provide skid resistance. The thickness of concrete slab is kept between 150mm to 300mm.

## 6.3 JOINTS

Joints are purposefully placed discontinuities in a rigid pavement surface course. The most common type of pavement joints, defined by their function, are (AASHTO, 1993): contraction, expansion, isolation and construction.

### CONTRACTION JOINTS

A contraction joint is a sawed, formed, or tooled groove in a concrete slab that creates a weakened vertical plane. It regulates the location of the cracking caused by dimensional changes in the slab. Unregulated cracks can grow and result in an unacceptabley rough surface as well as water infiltration into the base, subbase and subgrade, which can enable other types of pavement distress. Contraction joints are the most common type of joint in concrete pavements, thus the generic term "joint" generally refers to a contraction joint.

Contraction joints are chiefly defined by their spacing and their method of laod transfer. They are generally between 1/4 - 1/3 the depth of the slab and typically spaced every 3.1 - 15 m (12 - 50 ft.) with thinner slabs having shorter spacing. Some states use a semi-random joint spacing pattern to minimize their resonant effect on vehicles. These patterns typically use a repeating.

**Fig 6.3.1Pavement showing**

**Fig 6.3.2Missing**

**Contraction joint**

Sequence of joint spacing {for example: 2.7m (9 ft)} then 3.0m (10ft) the 4.3m (14 ft) the 4.0m (13 ft). Transverse contraction joints can be cut at right angles to the direction of traffic flow or at an angle (called a "skewed joint"). Skewed joints are cut at obtuse angles to the direction of traffic flow to help with load transfer. If the joint is properly skewed, the left wheel of each axle will cross onto the leave slab first and only one wheel will cross the joint at a time, which results in lower load transfer stresses.

**Fig6.3.3Skewed Contraction Joint**

**EXPANSION JOINTS**

An expansion joints is placed at a specific location to allow the pavement to expand without damaging adjacent structures or the pavement itself. Up until the 1950s, it was common practice in the U.S. to use plain, jointed slabs with both contraction and expansion joints (Sutherland, 1956). However, expansion joint are not typically used today because their progressive closure tends to cause contraction joints to progressively open (Sutherland, 1956).

Progressive or even large seasonal contraction joint opening cause a loss of load transfer - particularly so far joint without dowel bars.

**ISOLATION JOINTS**

An isolation joint is used to lessen compressive stresses that develop at T- and unsymmetrical intersections, ramps, bridges, building foundations, drainage inlets, manholes, and anywhere different movement between the pavement and a structure (or another existing pavement) may take place (ACPA, 2001). They are typically filled with joint filler material to prevent water and dirt infiltration.

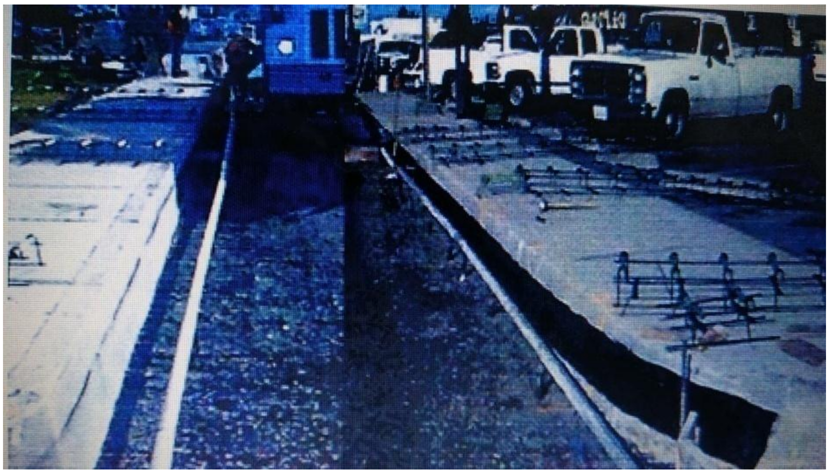


**Fig 6.3.4Roofing Paper Used For an Isolation Joint**

**CONSTRUCTION JOINTS**:

A construction joint is a joint between slabs that results when concrete is placed at different times. This type of joint can be further broken down into transverse and longitudinal construction joints. Longitudinal construction joints also allow slab warping without appreciable separation or cracking of the slabs.

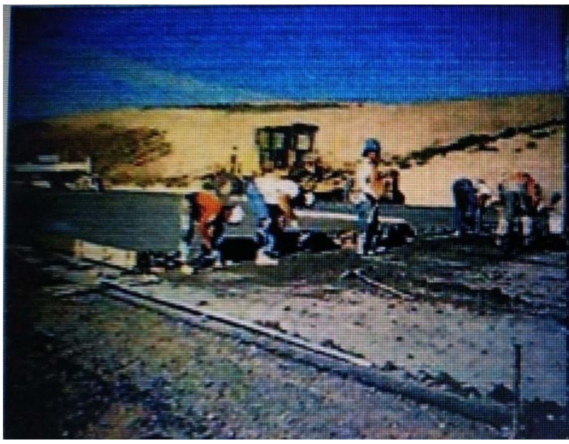


**Fig 6.3.5 Construction Joint**

**Fig 6.3.6 Longitudinal and Transverse Construction Joint**

**6.4 LOAD TRANSFER**:

"Local transfer" is a term used to describe the transfer (or distribution) load across discontinuities such as joints or cracks (AASHTO, 1993). When a wheel load is applied at a joint or crack, both the loaded slab and adjacent unloaded slab deflect. The amount the unloaded slab deflects is directly related to joint performance. If a joint is performing perfectly, both the loaded and unloaded slabs deflect equally. Load transfer efficiency is defined by the following equation:

Where $\Delta_2$ = approach slab deflection

$\Delta_1$ = leave slab deflection

This efficiency depends on several factors, including temperature (which affects joint opening), joint spacing, number and magnitude of load applications, foundation support, aggregate particle angularity, and the presence of mechanical load transfer devices. Most performance problems with concrete pavement are a result of poorly performing joints (ACPA, 2001). Poor load transfer creates high slab stresses, which contribute heavily to distresses such as faulting, pumping and corner breaks. Thus, adequate load transfer is vital to rigid pavement performance. Load transfer across transverse joints/cracks is generally accomplished using one of three basic methods: aggregate interlock, dowel bars, and reinforcing steel.

## 6.5 AGGREGATE INTERLOCK:

Aggregate interlock is the mechanical locking which forms between the fractured surface along the crack below the joint saw cut. Some low volume and secondary road systems rely entirely on aggregate interlock to provide load transfer although it is generally not adequate to provide long term load transfer for high traffic (and especially truck) volumes. Generally aggregate interlock is ineffective in cracks wider than about 0.9mm (0.035 inches). Often, dowel bars are used to provide the majority of load transfer.

**Fig 6.5.1Aggregate Interlock**

## 6.6 DOWEL BARS:

Dowel bars are short steel bars that provide a mechanical connection between slabs without restricting horizontal joint movement. They increase load transfer efficiency by allowing the leave slab to assume some of the load before the load is actually over it. This reduces joint deflection and stress in the approach and leave slabs.

Dowel bars are typically 32 to 38mm (1.25 to 1.5 inches) in diameter, 460mm (18inches) long and spaced 305mm (12 inches) apart. Specific location and numbers vary by state; however a typical arrangement might look like figure below. In order to prevent corrosion, dowel bars are either coated with stainless steel as (Figure A) or epoxy as (Figure B). Dowel are usually inserted at mid slab depth and coated with a bond breaking substance to prevent bonding to the PCC. Thus, the dowels help transfer load but allow adjacent slabs to expand and contract independent of one another. Figure B shows typical dowel bar locations at a transverse construction joint.

**Fig 6.6.1 dowel bar**

## 6.7 REINFORCING STEEL:

Reinforcing steel can also be used to provide load transfer. When reinforcing steel is used, transverse contraction joints are omitted. Therefore, since there are no joints, the PCC cracks on its own and the reinforcing steel provide load transfer across these cracks. Unlike dowel bars, reinforcing steel is bonded to the PCC on either side of the crack in order to hold the crack tightly together.

Typically, rigid pavement reinforcing steel consists of grade 60 (yield stress of 60 ksi (414 MPa) No. 5 or No. 6 bars (Eres, 2001). The steel constitutes about 0.6 - 0.7 percent of the pavement cross-sectional area (ACPA, 2001) and is typically placed at slab mid-depth orshallower. At lease 63mm (2.5 inches) of PCC cover should be maintained over the reinforcing steel to minimize the potential for steel corrosion by chlorides found in deicing agents (Burke, 1983).

## 6.8 TIE BARS

Tie bars either deformed steel bars or connectors used to hold the faces of abutting slabs in contact (AASHTO, 1993). Although they may provide some minimal amount of load transfer, they are not designed to act load transfer devices and should not be used as such (AASHTO, 1993). Tie bars are typically used at longitudinal joints Figure C or between an edge joint and a curb or shoulder. Typically tie bars are about 12.5mm (0.5inches) in diameter and betweeen 0.6 and 1.0m (24 and 40 inches long).

**Fig6.8.1 Tie Bars along a Longitudinal Joint**

## 6.9 FACTOR AFFECTING STABILITY OF PAVEMENT

The thickness of pavement depends on a number of varibles, but from experience, it has been found that the following five factors affect the performance of pavement to a great extent.

**TRAFFIC FACTORS**: These include the character and volume of traffic which will use the pavement.

**MOISTURE FACTORS**: These represent change of moisture content of the sub grade due to any of the conditions of precipitation, capillarity and irrigation in the area etc.

**CLIMATIC FACTORS**: These factors represent the effect of temperature changes such as frost penetration etc.

**SOIL FACTORS**: These factors represent the effect of the condition of natural foundation soil in cuts under shallow embankments or soil used in the embankment immediately underlying the subgrade surface. They measure the supporting power of the subgrade.

**STRESS DISTRIBUTION FACTORS**: These factors represent the function of pavement and base for transmitting the load of the subgrade.

**6.10 TRAFFIC FACTORS**:

Under this head following wheel load factors are considered in the design of pavement.

1. Maximum wheel load
2. Dual or Multiple wheel loads and equivalent single wheel load.
3. Load Contact pressure
4. Repetition of loads.

**MAXIMUM WHEEL LOAD**:

In the design of a pavement the knowledge of maximum wheel load is more important than gross weight of the vechicle. In evaluating the magnitude of the wheel load to be selected as design criterion, the legal axle load specified in the area should be taken into account. In India, Indian Road Congress has specified the maximum legal load as 8170 kg, and maximum equivalent single wheel load as 4085 kg. It has been observed that unless the two wheels are spaced sufficiently closely, the area of subgrade stressed by each wheel overlaps and as stated above in such cases the maximum whell load is more important than gross weight of the vehicle. The configuration or space of wheel load gives an idea how the load of a vehicle acts on the surface of the pavement.

Typical wheel load configuration of a tractor trailer unit of heavy duty vehicle.

The total load influences the thickness of the pavement while tyre pressure influences the quality of surface course. Actually the magnitude of vertical pressure at any depth of soil subgrade depends upon the surface pressure as well as on the total load.

The vertical stress at any depth can be computed by using B oussinesq equation reproduced below:

$\sigma_z = [1 - (z^3/(a^3 + z^3)^{3/2})]$

Where,

P = Surface pressure

$\sigma_z$ = Vertical stress at depth z a = Radium of located area

z = Depth at which stress is computed.

This equation is applied for uniformly distributed 4 d circular load. Using this equation the variation in vertical stress due to a load of 36 tonne acting over a, area of 30cm, radium has been plotted with depth.

**LOAD CONTACT PRESSURE**:

From the study of Figure it will be evident that the influence of tyre pressure is predominant in the upper layers. At greater depths the tyre pressure effect diminishes and the total load exhibits a considerable influence on the

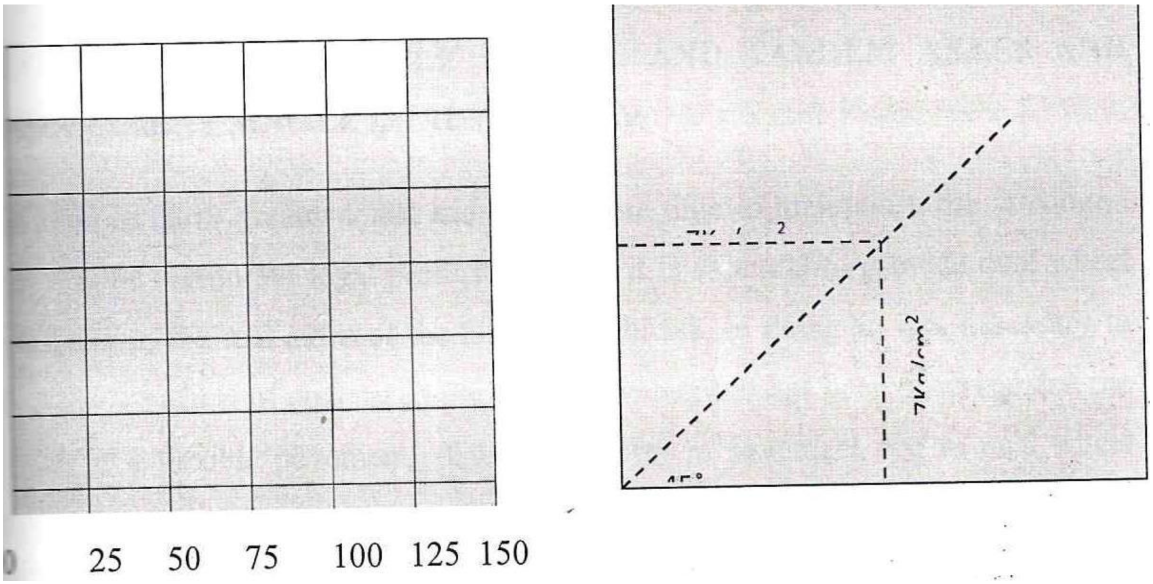



**Fig 6.10.1 Load contact Pressure**

The vertical stress magnitude. Thus to bear high magnitude of tyre pressure the upper layers of pavements should be of high quality materials. However, the tyre pressure does not affect the total depth (thickness) of the pavement. With constant pressure, the total load governs the thickness requirements of the pavements so that stress in the upper layer on top of the subgrade within allowable limits.

Usually the distribution of wheel load is assumed on a circular area, but by actual measurement of the imprint of types with different loads and inflation pressure, in many cases the contact area has been found as elliptical in shape. Thus contact pressure can found by the following equation.

Contact pressure = Load on wheel / Contact Area Where, Contact Area = 0.9 Wheel Load / Tyre Pressure

The contact area can also be found by taking actual impression of the tyre imprint. Generally the tyre pressure and contact pressure are same when the tyre pressure is 6 kg/$cm^2$. The ratio of contact pressure to tyre pressure is known as Rigidity factor. The value of rigidity factor is 1.0 for an average tyre pressure of 7.0 kg/$cm^2$. If the tyre pressure is lower than 7kg/$cm^2$. This ratio is higher than unity for higher pressure. Actually the rigidity factor depends upon the degree of tension developed in the walls of the tyres.

**EFFECT OF MULTIPLE WHEELS AND TANDEM AXLES AND EQUIVALENT SINGLE LOAD (E.S.W.L.)**:

In order to carry greater loads and at the same time to maintain the maximum wheel load within the legal prescribed limit, it is essential to provide dual wheel assembly to the real axles of the highway vehicles. In doing so it is necessary to find out the effect of dual assembly on the pavement. It has been observed that the depth of a flexible pavement, at which stress in pavement due to dual wheel assembly are equal to those of a single wheel assembly, depends upon the spacing of wheels.

**REPETITION OF LOAD:**

The deformation of subgrade or pavement due to a single application of wheel load may be very small, but the repeated application of load on the pavement may result in increased magnitude of plastic and elastic deformations. The accumulated permanent deformation even may cause failure of the pavement.

If the subgrade is poorly compacted or over stressed, the repeated loading may produce a permanent and non-uniform deformation of subgrade. This is more significant for rigid pavement as the reduced support is given by the subgrade may cause failure of the slab.

Laboratory as well as field plate loading tests have shown that the amount of deformation under repeated loads varies directly with the Logarithm of the load applications. This principle can be used to extend the load deformation data from few tests to a large number of repetitions. Thus it can be used to evaluate the supporting power of the subgrade for the anticipated load repetitions during the design life of the pavement, but the mixed traffic, traffic surveys are carried out to find out the repetition factor for wheel loads in the design of pavements. The data collected is converted to some constant equivalent wheel loads. Equivalent wheel loads are those loads which require same thickness and strengthor quality of pavement taking into account the repetition of each load. In India the traffic composition is of mixed type. Thus it is essential to convert the various wheel loads into one single wheel load for design purpose.

**Table: 6.10.1**

**AGGREGATE IMPACT VALUE TEST(AS PER IS 2386 PART -Ⅳ)**

**PROJECT:- C.S. INFRA CONSTRUCTION. Working on four lane cement concrete road from Km 1+1600 to Km 33+ 950 Gorakhpur to Maharajganj Nichalaul road SH-81**

| DESCRIPTION | 1 |
|---|---|
| Wt of sample measure | 321 |
| Wt of crushed material retrain is sieve 2.36mm(gm) | 259 |
| Wt of crushed material passing is sieve 2.36mm(gm) | 62 |
| Aggregate impact value | 19.31 |

**Table 6.10.2**

**GRADATION OF10mm COARSE AGGREGATE AS PER MOSRT AND H TABLE 1000-1**

**Total wt of sample(g) = 10995gm**

| SIEVE SIZE | WT RETAINED (GM) | CUMULATIVE WT RETAINED(GM) | %RETAINED | %PASSING | SPECIFICTION LIMIT |
|---|---|---|---|---|---|
| 20mm | 0 | 0 | 0 | 100 | 100 |
| 12.5mm | 387 | 387 | 3.52 | 96.48 | 90-100 |
| 10mm | 5488 | 5875 | 53.43 | 46.57 | 40-85 |
| 4.75mm | 4720 | 10595 | 96.36 | 3.64 | 0-10 |

**Table 6.10.3**

**CLAY BURNT BRICK/FLY ASH**

| SI .NO. | PRODUCT/MATRIAL PERFORMED | SPECIFIC TEST PERFORMED | TEST METHOD SPECIFICATION AGAINST WHICH TEST ARE PERFORMED | RANGE OF TESTING/LIMIT OF DETECTION |
|---|---|---|---|---|
| | CLAY BURN BRICKS/FLY ASH | WATER ABSORPTION | IS 3495 (PART 2):1992(RA2011) | 1%-3% |
| | | COMPRESSIVE STRENGTH | IS 3495(PART-1):1992 (RA 2011) | 3.5Mpa to 50Mpa |
| | | EFFLORESCENCE | IS 3495 (PART -3) :1992 (RA 2011) | Qualitative |
| | | DIMENSION | IS 1077:1992(RA 2011) | L = 4000mm to 5000mm<br>W= 2000mm to 3000mm<br>H = 1000mm to 2000mm |

## METAKAOLIN

Metakaolin is thermally activated ordinary clay and unpurified material show certain amount of pozzololanic properties are not highly reactive. Highly reactive metakaolin is made by water processing to remove impurity to make 100%reactive pozzolan. Such product white or cream in colour, purified thermally activated is called high reactive metakaolin. High reactive metakaolin show high pozzolonic reactivity. It has the ability to compete with silica fume and 5 to 10% replacement with cement can bring useful properties to concrete and substitute of silica fume. Silica fume shall comply with requirement given in IS:15388-2003, IS:456-2000, IRC :SP:76.

## TEST DONE FOR CEMENT

- Fineness test
- Standard consistency test
- Initial and final setting time

**Table 6.10.4**

**FINENESS OF CEMENT (IS 4031/ PART- IV)**

**PROJECT:- C.S. INFRA CONSTRUCTION. Working on four lane cement concrete road from Km 1+1600 to Km 33+ 950 Gorakhpur to Maharajganj Nichalaul road SH-81**

| TRIAL NO | IS SIEVE (mm) | Wt of sample (gram) | Wt of cement retained | % of retained | Average retained | Permissible limit is:8112 |
|---|---|---|---|---|---|---|
| 1 | 90mic | 100 | 3 | 3% | | less than 10% on 90 mic sieve |

**Table 6.10.5**

**STANDARD CONSISTENCY TEST OF CEMENT (IS : 4031/ PART - Ⅳ)**

**PROJECT:- C.S. INFRA CONSTRUCTION. Working on four lane cement concrete road from Km 1+1600 to Km 33+ 950 Gorakhpur to Maharajganj Nichalaul road SH-81**

| TRIAL NO | Wt of cement (gm) = A | Penetration of the plunger from the bottom of vicat mould (mm) | Is the penetration between 5 to 7mm (yes/no) | Standard consistency P=B/A×100 | WT OF WATER(gm)= B | REMARK |
|---|---|---|---|---|---|---|
| 1 | 400 | 7 | yes | 29% | 116 | |

**Table 6.10.6**

**INITIAL AND FINAL SETTING TIME (IS 4031/ PART-Ⅴ)**

**PROJECT:- C.S. INFRA CONSTRUCTION. Working on four lane cement concrete road from Km 1+1600 to Km 33+ 950 Gorakhpur to Maharajganj Nichalaul road SH-81**

| SI.NO. | Wt of cement (gm) | Water 0.85% of standard consistency (gm) | Time of adding water | Time when the needle fall to penetrate test block by 5±0.5mm | Time when needle make impression but the attachment fall to do so | Initial setting time 30 min |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | (5+4) |
| | 400 | 98.6 | 4.10 | 4S | 400min | |
| | | | | | Final setting time= 600min | |

Project: Construction of Fore Lane Cement Concrete Pavement road from Km. 1+600 To Km. 33+ 950 Gorakhpur to Maharajganj Nichalaul Road SH-81

Client: UP. PWD Contractor: C.S. Infra Construction

Gradation of Granular Sub Base Material

**CALIFORNIA BEARING RATION TEST**

As per IS: 2720 (Part-16)

**Table 6.10.7 California Bearing Ration Test**

| | | | |
|---|---|---|---|
| Source | : | Type of Compaction | |
| Location (Chinage) | : | MDD | 2.057 |
| Proposed Use | : | OMC | 10.58 |
| Above 19 mm replaced | : | Date of Sample | 01.07.2017 |
| Capacity of Mould | :2250 | Date of Testing | 04.07.2017 |
| Surcharge Weight | :2.5 kg. | Tested By | |

**Table 6.10.8 Moisture Content And Dry Density Of Test Sample**

| **Mould No.** | **3** | | **5** | | | |
|---|---|---|---|---|---|---|
| Condition of Sample | Before Soaking | After Soaking | Before Soaking | After Soaking | Before Soaking | After Soaking |
| Wt. of wet sample + mould | 11325 | | 11685 | | | |
| Wt. of Mould | 6638 | | 6292 | | 6375 | |
| Vol. of sample | | | | | | |
| Bulk Density of sample | | | | | | |
| Container No. | 5 | | 8 | | 2 | |
| Wt. of wet sample+container | 133.36 | | 82.09 | | 170.00 | |
| Wt. of Dry sample+container | 124 | | | | 157 | |
| Wt. of water | | | | | | |
| Wt. of container | 32.60 | | 34.85 | | 34.00 | |
| Moisture content (%) | | | | | | |
| Dry density of sample | | | | | | |

| (In MM) | Mould No.................................. Mould No............................................Mould No............................... | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Reading** | **LOAD (kg.)** | **Unit Load** | **CBR%** | **Reading** | **Load** | **Unit Load** | **CBR %** | **Reading** | **Load (k.g.** | **Unit Load** | **CBR %** | **Average** |
| 0.5 | 11 | 10 | | | 10 | | | | 6 | | | | |
| 1.0 | 23 | | | | 22 | | | | 14 | | | | |
| 1.5 | 41 | | | | 43 | | | | 30 | | | | |
| 2.0 | 63 | | | | 63 | | | | 50 | | | | |
| 2.5 | 102 | | | | 100 | | | | 74 | | | | |
| 3.0 | 160 | | | | 150 | | | | 84 | | | | |
| 4.0 | 250 | | | | 263 | | | | 110 | | | | |
| 5.0 | 210 | | | | 571 | | | | 170 | | | | |
| 7.5 | 390 | | | | | | | | 290 | | | | |
| 10.0 | | | | | | | | | | | | | |
| 12.5 | | | | | | | | | | | | | |

Remark:

..........................................................................................................................................

Contractor's Representative PWD Representative

MDD: Maximum dry density OMC: Optimum moisture content

The California bearing ratio test is a penetration test used to evaluate the sub grade strength of road and pavement. The result of these test are used with the curve to determine the thickness of pavement and its component layers.

## 6.11 AS PER IRC: 58-2015

For a four-lane divided national highway with two lanes in each direction in the state of Bihar design the pavement for periods of 30 years. Lane width=3.5m; Transverse joint spacing=4.5m.

- Selection of modulus of sub grade reaction:- Effective CBR of compacted sub grade=8% Modulus of sub grade reaction=50.3Mpa/m
- Provide 150mm thick granular sub base as per Morth 401.2.2
- Provide a DLC sub base of thickness 150mm with a minimum 7 days compressive strength of 7 Mpa.
- Provide PQC of 300mm with compressive strength between 35 to 45 N/mm2 in 28 days
- Effective modulus of sub grade reaction of combined foundation of sub grade + GSB and DLC sub base (from table 4 by interpolation ) =285Mpa/m.
- Provide a debounding layer of polythene sheet of 125 micron thickness between DLC and concrete slab.
- Slump value of DLC is 0 where as slump value of PQC 25±15
- Selection of flexural strength of concrete
- 1:- 28 days compressive strength of cement concrete less then equals to 40 Mpa 2:- 90 days compressive strength of cement concrete less then equals to 48 Mpa 3:- 28 days flexural strength of cement concrete =4.5 Mpa (minimum)
- 4:- 90 days flexural strength of cement concrete =4.5 *1.1=4.95 Mpa

## 6.12 INDIAN STANDARD CONCRETE MIX PROPORTION

Method recommended for concrete mixes design (IS 10262-1982) according to Indian standard was introduced during year 1982. To revise in IS 10262 of 1982 a number of changes were introduced in IS 456:2000. A committee was set up to review the method of mix design in conformity with IS 456:2000. The committee took long time and come up with a new guideline for concrete mix proportioning.

Based on IS 10262:2009 for concrete mix proportioning Data required for mix proportioning

1:-Grade of concrete

2:-Maximum size of aggregates 3:-Minimum cement content

4:-Maximum w/c ratio

5:-Workability in terms of slump 6:-Exposure condition

7:-Maximum temperature at the pouring point 8:-Early age strength (if required)

9:-grading zone of fine aggregates 10:-Type of aggregates

11:-Maximum cement content

12:-Admixture used (Brand name)

13:-Specific gravity of all materials used and dosage

Target mean strength

Concrete mix should be designed for certain higher strength than characteristic strength and assume 5 percent of the site result are allowed to fall below the characteristic strength.

Target mean strength given by:-

$f'ck = f\ ck + t*s$

$f'ck = f\ ck + 1.65s$ (1.65 is applicable for 5 % of the result is allowed to fall below the characteristic strength). For other cases refer the below table

**Table 6.12.1: Value of tolerance factor (t) (risk factor)**

| TOLERACE LEVEL NUMBER OF SAMPLE | 1in10 | 1in15 | 1in 20 | 1in 40 | 1in 100 |
|---|---|---|---|---|---|
| 10 | 1.37 | 1.65 | 1.81 | 2.23 | 1.76 |
| 20 | 1.32 | 1.58 | 1.72 | 2.09 | 2.53 |
| 30 | 1.31 | 1.54 | 1.70 | 2.04 | 2.46 |
| Infinite | 1.28 | 1.50 | 1.64 | 1.96 | 2.33 |

.f̀ck=Target mean compressive strength in 28 days f ck=Characteristic compressive strength in 28 days t=tolerance factor

S= standard deviation indicates the level of quality control exercised at the site

**Table 6.12.2: Standard deviation**

| GRADE OF CONCRETE | ASSUME STANDARD DEVIATION N/mm2 |
|---|---|
| M10<br><br>M15 | 3.5 |
| M20 M25 | 4.0 |
| M30 M35 M40 M45 M50 M55<br><br>M60 | 5.0 |

**SELECTION OF W/C RATIO**

1:-Use one's experience in fixing the w/c ratio

2:-Use the water cement ratio, successfully used in the neighboring project or in the project successfully completed recently using nearly similar materials

**SELECTION OF WATER CONTENT**

Number of factor influenced the water content of concrete such as shape, size, texture, workability, cement, and chemical admixture. Increase in aggregates size, slump reduction, use of natural sand, use of plasticizer, w/c ratio reduction reduces water content. Larger percentage of fine aggregates when compared to coarser aggregates will increase the water content.

Maximum water content per cubic meter of concrete for nominal maximum size of aggregate

**Table 6.12.3: Nominal maximum size of aggregate and maximum water content**

| Serial number | Nominal maximum size of aggregate mm | Maximum water content Kg |
|---|---|---|
| 1 | 10 | 208 |
| 2 | 20 | 186 |
| 3 | 40 | 165 |

NOTE:-

1:-These quantities of mixing water are for use in computing cementitious materials contents for trial batches.

2:-Water content corresponding to saturated surface dry aggregates.

**Calculation of cementitious material content**

Cement plus supplementary cementitious materials content per unit volume of concrete may be calculated from free w/c ratio and the quantity of water per unit volume of concrete.

The cementitious materials content so calculated shall be checked against the minimum cementitious content for the durability requirement and greater of the two values adopted. The minimum cement content is given below in the table

**Table 6.12.4: Minimum cement content, maximum w/c ratio and minimum grade of concrete for different exposures with nominal weight aggregates of 20 mm nominal maximum size, IS 456:2000**

| Sl. No. | Exposure | Plain concrete | | | Reinforced Concrete | | |
|---|---|---|---|---|---|---|---|
| | | Minimum cement contents kg/m3 | Maximum free w/c ratio | Minimum grade of concrete | Minimum cement content kg/m3 | Maximum free w/c ratio | Minimum grade of concrete |
| 1 | Mild | 220 | 0.60 | - | 300 | 0.55 | M20 |
| 2 | Moderat E | 240 | 0.60 | M15 | 300 | 0.50 | M25 |
| 3 | Severe | 250 | 0.50 | M20 | 320 | 0.45 | M30 |
| 4 | Very Severe | 260 | 0.45 | M20 | 340 | 0.45 | M35 |
| 5 | Extreme | 280 | 0.40 | M25 | 360 | 0.40 | M40 |

**Estimate of coarse aggregate proportion**

Aggregate of the same nominal maximum size, type and grading will produce concrete of satisfactory workability when a given volume of coarse aggregates is used. Approximate aggregate volume is given below in the table for a w/c ratio of 0.5. This aggregates volume may be adjusted for other w/c ratio in the following way. For every decrease of w/c by 0.05, the coarse aggregate volume may be increased by 1 percent to reduce the sand content and for every increase of w/c ratio by 0.05 the coarse aggregate volume may be decreased by 1.0

percent to increase the sand content.

For more workable mixes for pumping or tremie concreting, it may be desirable to reduce the coarse aggregate content by about 10 percent. Care must be taken to obtain proper slump and w/c ratio.

**Table 6.12.5: Volume of coarse aggregate per unit volume of total aggregate for different zones of fine aggregate for w/c ratio of 0.5**

| Sl. No. | Nominal maximum size of aggregate Mm | Volume of coarse aggregate per unit volume of total aggregates for different zone of fine aggregates | | | |
|---|---|---|---|---|---|
| | | Zone 4 | Zone | Zone | Zone |
| | | | 3 | 2 | 1 |
| 1 | 10 | 0.50 | 0.48 | 0.46 | 0.44 |
| 2 | 20 | 0.66 | 0.64 | 0.62 | 0.60 |
| 3 | 40 | 0.75 | 0.73 | 0.71 | 0.69 |

**Note:-Volume are based on aggregates in saturated and surface dry condition.**

Combination of different coarse aggregates fraction

Coarse aggregates are different size may be combined in different proportion so as to get overall grading conforming to grading given table 2 of IS 383.

**Estimate of fine aggregate proportion**

From all the above steps, we have estimated the proportion of all the ingredients except coarse and fine aggregates. As a next step, find out the absolute volume of the entire so far known ingredient. Deduct the sum of all the known absolute volume from unit volume, the result will be the absolute volume of coarse and fine aggregates put together. We know the volume of coarse aggregates and hence volume of fine aggregates can be calculated.

**Trial mixes**

With the last step; the weight of the entire ingredient in kg/m3 can be found out.

The weight of coarse aggregate and fine aggregate are in saturated and surface dry condition. Depending upon the absorption characteristic or presence of surface, moisture, make the field correction as worked out in the earlier mix design example. In the laboratory carry out trial number

Observe the workability bleeding and segregation characteristic and cohesiveness of concrete etc. The measured workability in terms of slump or flow value is different from stipulated value, the water and/ or admixture content may be adjusted suitably. With the adjustment, the mix proportion will be recalculated, keeping the w/c ratio at the pre-selected value, which will compromise trial mixture 2. In addition, two more trial mixes number 3 and 4 shall be made with water content same as trial mix number 2 and varying the w/c ratio by ±10 percent of the preselected value.

Mix number 2 to 4 normally provides sufficient information; include the relationship between compressive strength and w/c ratio.

Design a concrete mix for M45 grade of concrete with following data

| | |
|---|---|
| 1:-Type of cement | OPC 43 grade |
| 2:-Maximum size of aggregate | 20mm |
| 3:-Exposure condition | Severe |
| 4:-Workability | 125 mm slump |
| 5:-Minimum cement content | 320kg/m3 |
| 6:-Maximum w/c ratio | 0.45 |
| 7:-Method of placing concrete | pumping |
| 8:-Degree of supervision | good |
| 9:-Type of aggregate crushed angular agg. | 10:-Super plasticizer will be used |

11:-Specific gravity of coarse aggregate 2.80

12:-Specific gravity of fine aggregate 2.70

13:-Water absorption

Coarse aggregate 0.5%

Fine aggregate 1.0%

14:-Free surface moisture

Coarse aggregate nil

Fine aggregate nil

15:-Grading of coarse aggregate conforming to table 2 of IS 383

16:-Grading of fine aggregate conforming to grading zone 2

Target mean strength

Characteristic strength fck=45

Target mean strength f̀ck= fck+ 1.65×5

= 45+ 1.65×5 = 53.25 N/mm2

Where S is the standard deviation taken as 5 N /mm2

Water/cement ratio

Water/cement ratio is taken from the experience of the mix designer based on his experience of similar work elsewhere.

W/C= 0.42

This water cement ratio is to be selected both from strength consideration and the maximum w/c denoted in table 5 of IS 456 and lesser of the two is to be adopted for durability requirement.

w/c ratio mention in table IS 456 is 0.45. W/C proposed is 0.42. This being lesser than 0.45, we should adopt W/C ratio as 0.42

Selection of water content

Maximum water content as per table is 186 litre. This is for 50 mm slump. Estimated water content for 125 mm slump = 186×9/100+186

(3% increase for every 25 mm slump over and above 50 mm slump) = 203 litre

Really speaking separate trials are required to be done to find out the efficiency of super plasticizer. (How to find out the efficiency of plasticizer has been worked out from below table)

**Table 6.12.6: Efficiency of admixture by marsh cone test**

| Admixture | Qty of cement gm | w/c ratio | Quantity of water used gm | Dose of admix | Marsh cone time (sec) | Efficiency of admix |
|---|---|---|---|---|---|---|
| Brand X | 2000 | 0.6 | 1200 | 0 | 46 | 1200-830/1200<br>=0.3083<br>=0.3083×100 |
| | 2000 | 0.6 | 1200 | 1% | 33 | |
| | 2000 | | 1100 | 1% | 35 | |
| | 2000 | | 1000 | 1% | 38 | =30.8% |
| | 2000 | | 900 | 1% | 40 | |
| | | | 850 | 1% | 43 | |
| | | | 800 | 1% | 49 | |
| | | | 830 | 1% | 46 | |

Note:-The admixture Brand X with the type of cement used permits the reduction of 30.8% of water.

In the absence of such trial, it is assumed that the efficiency of super plasticizer used as 25%. Therefore actual water is to be used = 203×0.75=152 litre.

**Calculation of cement content**

W/C ratio = 0.42 Water used = 152 litre

Cement content = w/c

C =152/0.42 = 36.2 kg/mm2

**Calculation of coarse and fine aggregate content**

From the above table volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate Zone 2, for w/c ratio is found out to be 0.62.

In the present case w/c 0.42 i.e. it is less by 0.08. As the w/c is reduced it is desirable to increase the coarse aggregate proportion to reduce the fine aggregate content.

The coarse aggregate is increased at the rate of 0.01 for every decrease in w/c ratio is 0.05

0.01/0.05 × 0.08 = 0.016

Volume of C.A. = 0.62

= 0.016/0.636

Therefore, Corrected proportion of volume of CA =0.636

Since it is angular aggregate and the concrete is to be pumped, the coarse aggregate can be reduced by 10%.

Therefore, final volume of coarse aggregate = 0.636×0.9 = 0.572 Therefore, volume of fine aggregate = 0.43

**Calculation of mix proportion**

Volume of concrete = 1 m3

Absolute volume of cement = 362/3.15 × 1/1000 m3

= 0.115 m3

Volume of water = 152 litre = 0.152 m3 Volume of chemical admixture = 1.2×362/100×1=3.94

= 3.94/1000= 0.004 m3

(Assuming dosage of 1.2% by weight of cementitious material and assuming specific gravity of admixture as 1.1)

Absolute volume of all the material except total aggregate = 0.115 + 0.152 + 0.004 = 0.271 m3 Absolute volume of total aggregate = 1 – 0.271 = 0.729 m3

Weight of coarse aggregate = 0.729 × 0.57 × 2.80 × 1000 = 1163 kg/m3

Weight of fine aggregate = 0.729 × 0.43 × 2.70 × 1000 = 846 kg/m3

Therefore, wet density of concrete = 2527 kg/m3 w/c ratio is 0.42

The above quantity of aggregate is on saturated and dry surface condition. At the site it is given in the problem that the aggregate are absorptive and there is no surface moisture. It is required to make the necessary correction for the actual site condition of the aggregates, with respect to absorption characteristics.

Site correction

Absorption of fine aggregate = 1.0%

= 1/100 × 846 = 8.46 litre

Absorption of coarse aggregate = 0.5/100 × 1163 = 5.82 litre

Total absorption = 14.28 litre

Therefore, Actual amount of water to be used = 152 + 14.28 = 166.28 kg/m3

Actual weight of fine aggregate to be used = 846 – 8.46 = 837.5 kg/m3 Actual weight of coarse aggregate to be used = 1163 – 5.82 = 1157.20 Admixture = 4.0 kg/m3

With the above proportion of material carry out trial mix number 1 and see the quality of concrete. If it is not satisfactory carry out trial mix number 2, 3 and 4 as indicated earlier under trial mixes. Arrive at the final proportion of concrete mix to satisfy the required parameters.

**Table 6.12.7 FLEXURAL STRENGTH OF PQC (IS: 516)**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Project | : Consfruction of Fore Lane Cement Concrit Pavement Road From Km. 1+600 to Km. 33+950 Gorakhpur to Maharajganj Nichalaul Road, Sh-81 | | | | | | | | | |
| Client | : PWD GORAKHPUR (UP) | | | | | | | | | |
| Contractor | : C.S. INFRA CONSTRUCTION Ltd. | | | | | | | | | |
| **FLEXURAL STRENGTH OF PQC (IS: 516)** | | | | | | | | | | |
| Date of Testing | | | Grade of Concrete | | | | | | | |
| Sr. No. | Date of Casting | Streucture/ Location | ID Mark | Age/ Days | Dimonsion CM L*B*D | Flexural Distance "a" (cm) | Weight (Gm) | LOAD "P" (KN) | Flex Strength N/mm2 | Avg Flex Strength N/mm2 |
| | | | 1 | 28 day | 600x150x150 | 27 | 38936 | 28 | 4.98 | |
| | | | 2 | | | 26 | 38839 | 28 | 4.98 | 4.92 |
| | | | 3 | | | 25 | 38796 | 27 | 4.98 | |
| 1. Fn= P*L/B*D2, Where a>20 CM for 15cm Specimen or Where a> 13.3 cm For 10 cm Specimen | | | | | | | | | | |
| 2. Fn= 3P*a/B*D2, Where 20>a>17 CM Specimen or Where a 13.3 >a> 11cm For 10 cm Specimen | | | | | | | | | | |
| 3. Discard Where a> 17 CM 15 CM Specimen or Where a > 11cm For 10 cm Specimen | | | | | | | | | | |

As we know that PQC cost approximately 85000 Rs per 10 cubic meter i.e. 8500Rs per 1 cubic meter and for dry lean concrete (DLC) it cost approximately 4000Rs per cubic metre

**Table 6.12.8**

**TRIAL MIX DESINGS FOR M40 PQC IN CONVENTIONAL METHOD OF 1m³**

**Data from C.S. INFRA CONSTRUCTION. Working on four lane cement concrete road from Km 1+1600 to Km 33+ 950 Gorakhpur to Maharajganj Nichalaul road SH-81**

| **GRADE OF CONCRETE** | **M40 (PQC)** |
|---|---|
| CEMENT OPC(43) GRADE (kg) | 332/168 kg<br>cement and fly ash |
| 20mm KABRAI (kg) | 712 |
| 10mm KABRAI (kg) | 516 |
| SAND (SONE RIVER) (kg) (Zone Ⅰ) | 641 |
| ADMIXTURE (CONPLANT PC – 50) (SUPERPLASTICIZER) | 2.66 |
| WATER (liter) | 149 |
| CEMENT (BRAND) | Prism OPC - 43 |

## COMPRESSIVE STRENGTH TEST

- Cube size is off 15cm×15cm×15cm and filling should be done in three part with 35 stoke at each layer and the rod size is 16mm and 600mm length oiling should be done inside the cube then after filling is done cube should left for 24 hour and when cube is taken out from the mould it should be placed with wet cloth to maintain temperature 27 to 30˚C before curing now cube should be immersed in to water and the temperature should 27 to 30˚C
- Now for testing we will use compression testing machine before placing the cube between the plate cube should be clean, placed properly and load of 140 kg/mm2 is applied and the load at which cube form crack is noted down and compressive strength is found out by dividing load by its area.

**Table 6.12.9 Compressive Strenth Of Trial Mixs**

<table>
<tr><td colspan="8">COMPRESSIVE STRENGTH OF CONCRETE CUBES (IS-516-1956)<br>Location of .C. Laboratory :<br>Structure Location : Grade of Concrete<br>Part of Structure : Date of Casting</td></tr>
<tr><td rowspan="2">Cube No.</td><td rowspan="2">Date of Testing</td><td rowspan="2">Age</td><td rowspan="2">Weight of Cube (gm)</td><td rowspan="2">Density of Cube (gm/m3)</td><td>Load in KN</td><td>Strength.N/mm2</td><td rowspan="2">Average compressive strength (N/MM2)</td></tr>
<tr><td>Days</td><td>Days</td></tr>
<tr><td>1</td><td></td><td>28day</td><td>8443</td><td>2.502</td><td>1050</td><td>46.67</td><td></td></tr>
<tr><td>2</td><td></td><td></td><td>8550</td><td>2.520</td><td>1000</td><td>47.55</td><td>46.81 N/mm2</td></tr>
<tr><td>3</td><td></td><td></td><td>8418</td><td>2.494</td><td>1040</td><td>46.22</td><td></td></tr>
</table>

**GRAPH SHOWING CONPRESSIVE STRENGTH FOR THE CONVENTIONAL FORM OF TRAIL MIX**

**Density =** weight/volume

**Compressive strength =** load/area

= 1050 KN/ 2250 mm2

= 0.466 KN/mm2 × 100

= 46.6 N/mm2

**Area =** 150×150 mm

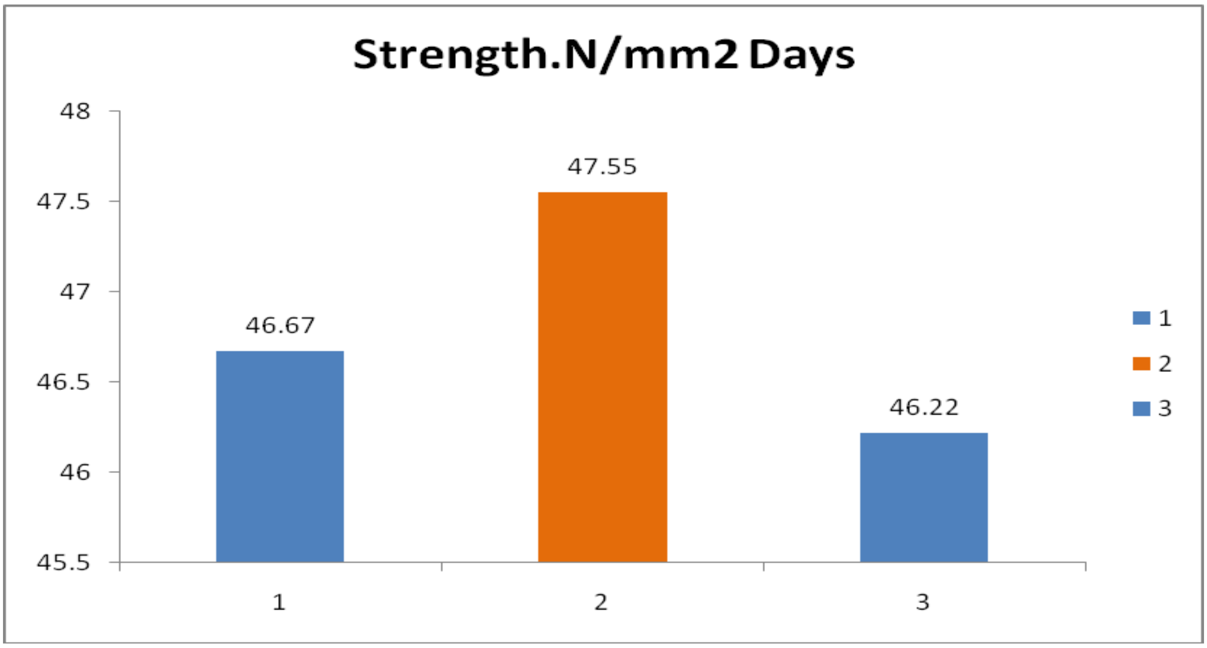



**Fig 6.12.1 Showing Conpressive Strength For The Conventional Form Of Trail Mix**


**Fig 6.12.2 COMPRESSIVE STRENGTH TESTING MACHINE**

## FLEXURAL STRENGTH TEST

- Concrete as we know is relatively strong in compression and weak in tension. In reinforced concrete members, little dependence is placed on the tensile strength of concrete since steel reinforcing bars are provided to resist all tensile forces.

- However, tensile stresses are likely to develop in concrete due to drying shrinkage, rusting of steel reinforcement, temperature gradient and many other reasons. Therefore, the knowledge of tensile strength of concrete is of importance.

- A concrete road slab is called upon to resist tensile stresses from two principal sources wheel load and volume change in the concrete. Wheel load may cause high tensile stresses due to bending, when there is an inadequate sub grade support.

- Volume changes, resulting from changes in temperature and moisture, may produce tensile stresses, due to warping and due to the movement of the slab along the sub grade.Stresses due to volume changes along may be high.

- The longitudinal tensile stress in the bottom of the pavement, caused by restraint and temperature warping, frequently amounts to much as 2.5 Mpa at certain periods of the year and the corresponding stress in the transverse direction is approximately 0.9 Mpa.

- These stresses are additive to those produce by wheel loads on unsupported portions of the slab.

**Table 6.12.10 Flexural Strength Of Trial Mix**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Project** | **: Consfruction of Fore Lane Cement Concrit Pavement Road From Km. 1+600 to Km. 33+950<br>Gorakhpur to Maharajganj Nichalaul Road, Sh-81** | | | | | | | | | |
| **Client** | **: PWD GORAKHPUR (UP)** | | | | | | | | | |
| **Contractor** | **: C.S. INFRA CONSTRUCTION Ltd.** | | | | | | | | | |
| **FLEXURAL STRENGTH OF PQC (IS: 516)** | | | | | | | | | | |
| **Date of Testing** | | | **Grade of Concrete** | | | | | | | |
| **Sr. No.** | **Date of Casting** | **Streucture / Location** | **ID Mark** | **Age/ Days** | **Dimension CM L*B*D** | **Flexural Distance "a" (cm)** | **Weight (Gm)** | **LOAD "P" (KN)** | **Flex Strength N/mm2** | **Avg Flex Strength N/mm2** |
| | | | **1** | **28 day** | **60x15x15** | **27** | **38936** | **28** | **4.98** | |
| | | | **2** | | | **26** | **38839** | **28** | **4.98** | **4.92** |
| | | | **3** | | | **25** | **38796** | **27** | **4.98** | |
| **1. Fn= P*L/B*D2, Where a>20 CM for 15cm Specimen or Where a> 13.3 cm For 10 cm Specimen** | | | | | | | | | | |
| **2. Fn= 3P*a/B*D2, Where 20>a>17 CM Specimen or Where a 13.3 >a> 11cm For 10 cm Specimen** | | | | | | | | | | |
| **3. Discard Where a> 17 CM 15 CM Specimen or Where a > 11cm For 10 cm Specimen** | | | | | | | | | | |

## FLEXURAL STRENGTH FOR CONVENTIONAL TRIAL MIX

a= the smallest part of the broken casting beam in a flexural beam machine
p= load in KN applied on a casting beam in a flexural beam machine.

Flexural strength= P× l/b×d2
= 28×600/3375
= 4.98 N/mm2

The above result of flexural strength is taken with trial mix table above in which no alternative is added.

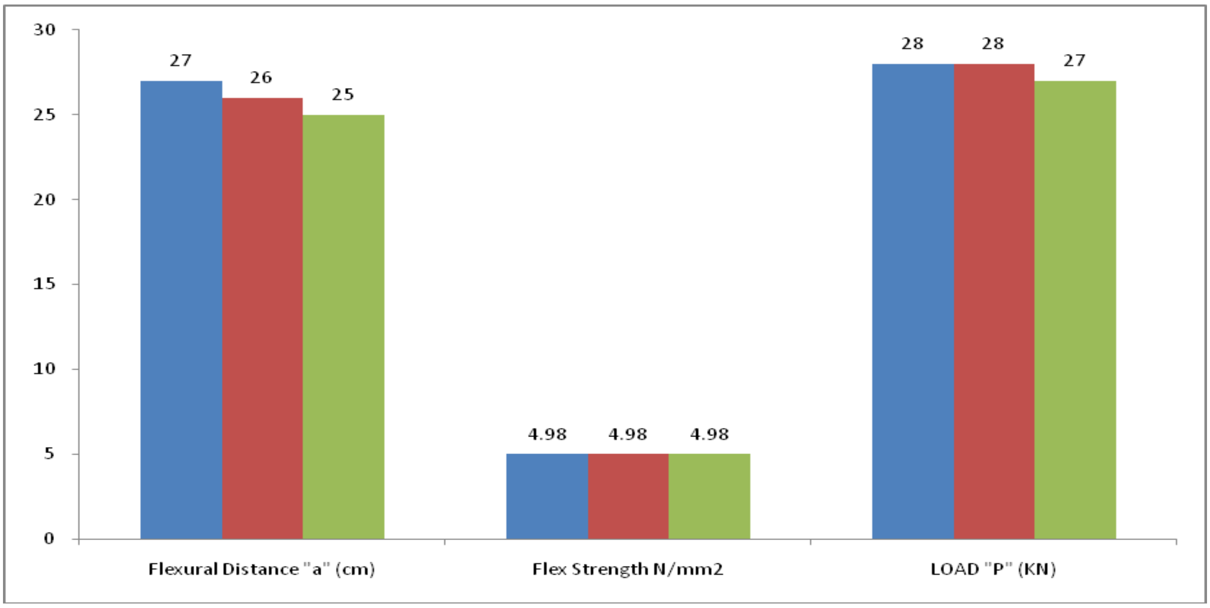



**Fig 6.12.3 For Flexural Strength For Conventional Trial Mix**

## PROPERTIES OF CERAMIC WASTE

The specific gravity is estimated to be 2.717 and 98.5 % of ceramic dust passed through the sieve of 0.075mm(75 micron). The chemical properties were given in with the compliance of test method IS 3812.

**Table 6.12.11 Test Description**

| S.NO. | Test description | Result |
|---|---|---|
| **1** | Aluminium oxide | **32.43%** |
| **2** | Calcium oxide | **2.16%** |
| **3** | Ferric oxide | **1.152%** |
| **4** | Magnesium oxide | **0.251%** |
| **5** | Potassium oxide | **0.009%** |
| **6** | Silicon oxide | **60.21%** |
| **7** | **Sodium oxide** | **0.093%** |

**Fig 6.12.4 Ceramic Waste In Dust Form**

**Table 6.12.12**
**TRIAL MIX IS DONE AS PER IS 10262:2009 FOR CERAMIC WASTE WHICH REPLACE CEMENT WITH 20%**

Data from C.S. INFRA CONSTRUCTION. Working on four lane cement concrete road from Km 1+1600 to Km 33+ 950 Gorakhpur to Maharajganj Nichalaul road SH-81

| **GRADE OF CONCRETE** | **M40(PQC) WITH 10% REPLACEMENT OF CEMENT WITH CERAMC WASTE MIXING IS DONE AS PER IRC 10262:2009** | **M40(PQC) WITH 20% REPLACEMENT OF CEMENT WITH CERAMC WASTE MIXING IS DONE AS PER IRC 10262:2009** | **M40(PQC) WITH 30% REPLACEMENT OF CEMENT WITH CERAMC WASTE MIXING IS DONE AS PER IRC 10262:2009** |
|---|---|---|---|
| **CEMENT OPC(43) GRADE (kg)** | **298.8+33.2+168 CEMENT+CERAMIC WASTE+FLY ASH** | **266+66+168 CEMENT+CERAMIC WASTE+FLY ASH** | **236+96+168 (CEMENT+CERAMIC WASTE+FLY ASH)** |
| **20mm KABRAI (kg)** | **712** | **712** | **712** |
| **10mm KABRAI (kg)** | **516** | **516** | **516** |
| **SAND (SONE RIVER) (kg)** | **641** | **641** | **641** |
| **ADMIXTURE (CONPLANT PC – 50)** | **2.66** | **2.66** | **2.66** |
| **WATER (liter)** | **149** | **149** | **149** |
| **CEMENT (BRAND)** | **PRISM OPC-43** | **PRISM OPC-43** | **PRISM OPC-43** |

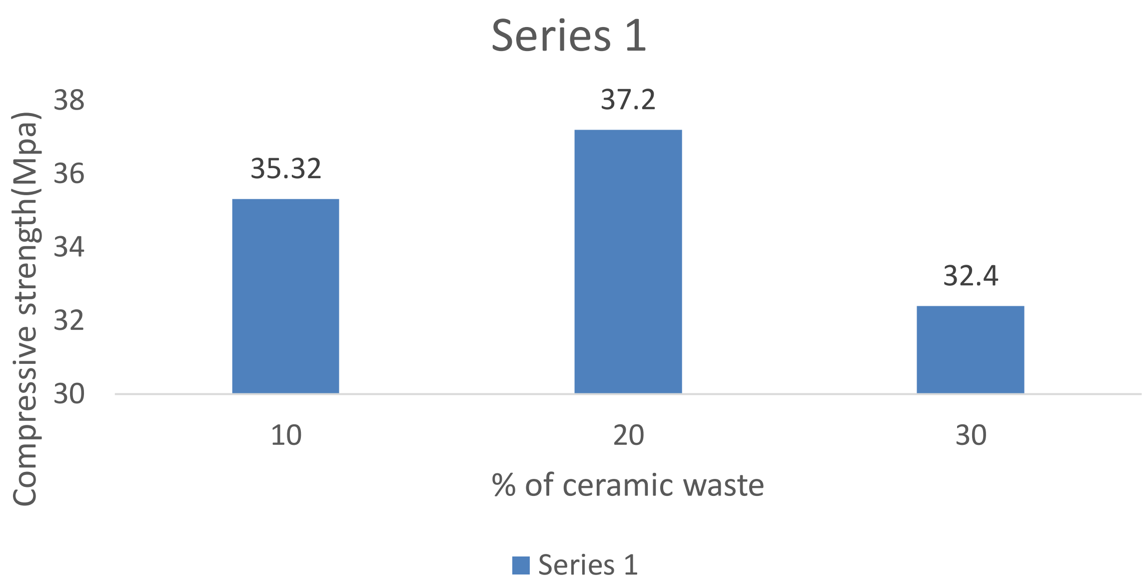



**Fig 6.12.5 Showing Compressive Strength Graph When Ceramic Waste Is Added In Conventional Form Of Trial Mix In 28 Days**

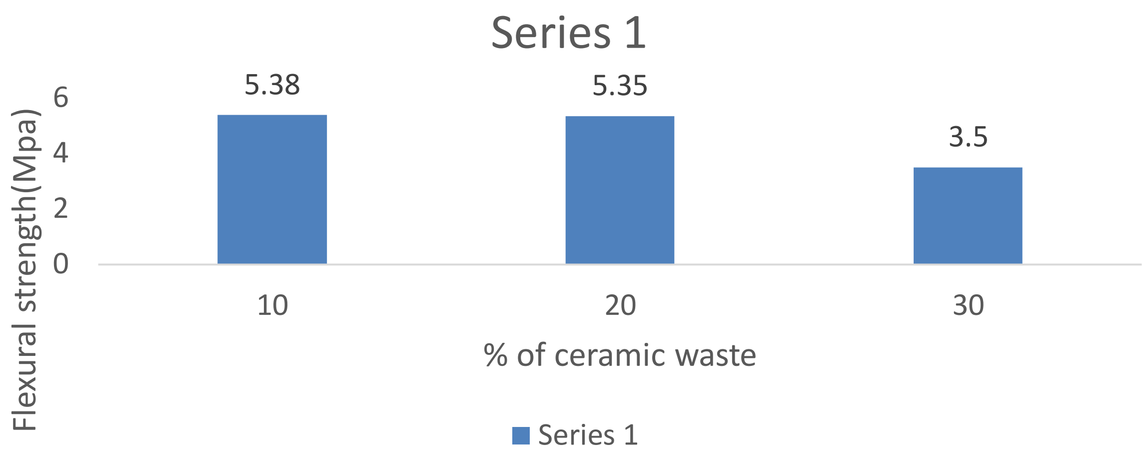



**Fig 6.12.6 Showing Flexural Strength Graph Using Ceramic Waste In Conventional Trial Mix In 28 Days**

**COMPARISION OF COST OF CEMENT, FLY ASH, CERAMIC WASTE**

As we know that PQC cost approximately 85000 Rs per 10 cubic meter i.e. 8500Rs per 1 cubic meter and for dry lean concrete (DLC) it cost approximately 4000Rs per cubic meter.

We take labour charge as 400rs for 8 hour work.

**Table 6.12.13 Comparison of Cost Of Cement, Fly Ash, Ceramic Waste**

| **MATERIALS (COST)** | **M40 PQC** | **M40 PQC WITH 20% REPLACEMENT WITH CERAMIC WASTE** |
|---|---|---|
| CEMENT/FLY ASH/ CERAMIC WASTE (KG) | 332/168<br>332×8 + 168×1 = 2824 RS | 266/168/66<br>2494RS |
| SAND (KG) | 641×0.65 = 416.65 | 416.65 |
| 20mm (KG) | 712×0.7 = 498.4 | 498.4 |
| 10mm(KG) | 516×0.66 =340.56 | 340.56 |
| ADMIXTURE (KG) | 2.66×90 = 239 | 239 |
| TOTAL COST | 4318.61 RS | 3988.61RS |

# RESULT

- The result show we can save 330 Rs by using ceramic waste as a partial replacement of cement in Concrete mix design for PQC and experimental show significance result by using ceramic as partial replacement of cement.
- Ceramic waste show good cementitious property. Trial mix design is done as per IS 10262: 2009.
- Test is being conducted with the help of trial mix table in which cement is replaced with the ceramic waste and after conducting the test the compressive strength is being tested on cube casted with replacement of ceramic waste and compressive strength is taken which is shown in graph and showed a satisfactory result as well as flexural test is done and result is shown in the graph and result is satisfactory as well.

# CONCLUSION

- Based on experiment investigation on cement replacement with ceramic waste in PQC and DLC within a range of 20% give a required compressive strength as well as flexural strength.
- It is found out that some alternative materials like GGBS, ceramic waste, silica fume, rice husk have good cementitious property.
- A partial replacement of cement with silica fumes up to 10-15% for attaining satisfactory result.
- Cement can be replaced with GGBS in concrete up to 50% without considerably change in strength perimeters and result can optimum at 30-40% replacement level.
- Laboratory investigation on more such type of new and innovative materials usage in concrete making should be encouraged to achieve a goal of sustainable pavement construction and low cost.
- The usage of these waste in pavement construction help in reducing environmental disposal issue and there by leading to sustainable construction.
- The trial mix is done as per IS 10262-2009
- The price is reduced which makes pavement more economical without compromising of the strength parameters. The slump value of ceramic waste concrete lies between 75 to 100 mm
- 20% replacement of ceramic waste content slightly decrease at all w/c ratio but within limit.
- A field study may be undertaken at different climatic traffic condition on NH OR SH road.
- The strength of concrete depend upon the standard deviation in $N/mm^2$ in the formula

$f'ck = fck + 1.65 \times S$

- We will take value of tolerance factor (t) in designing strength of concrete.

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