Economic Evaluation of Plastic Filled Concrete Block Pavement

Yendrembam Arunkumar Singh, Taiborlang Lyngdoh Ryntathiang, Konjengbam Darunkumar Singh

Abstract— This paper presents economic evaluation of Plastic Cell filled Concrete Block Pavement (PCCBP) over conventional flexible and Concrete pavements for low volume rural roads. The cost comparison has been carried out considering both construction and maintenance cost for a period of 5 years, based on design analysis and performance studies of 100 mm thick PCCBP laid over 100 mm thick WBM sub-base course. It has been observed that the initial construction costs for both flexible and rigid pavement were higher than that of PCCBP by ~9% and~150% respectively and the total cost (including maintenance cost for 5 years) of flexible and rigid pavement are found to be higher by ~43% and~141% respectively as compared to that of PCCBP. Cent percent replacement of river sand in concrete by waste stone dust proved to be cost cutting without significant change in strength of the concrete.

Index Terms— ABAQUS, BACKGA, Falling Weight Deflectometer (FWD), KENLAYER, Low volume roads, Plastic Cell Filled Concrete Block Pavement (PCCBP), Stone dust.

I. INTRODUCTION

In India, the proportion of low volume rural roads is about 80% of the total road length (NHAI, 2011). As such pavement engineers and researchers are concerned for designing sustainable rural roads with reasonable riding quality and with an emphasis on 'low life cycle cost'. Whilst conventional flexible pavement with a thin cover of premix bituminous carpet is normally adopted for rural roads, frequent maintenance are required (to maintain both functional and structural efficiencies) due to damages caused by poor drainage conditions, overloaded vehicular traffic, iron wheeled bullock carts etc. As a result such pavement incurs huge maintenance cost. To offset such expensive maintenance cost, concrete pavements are increasingly used in rural road connectivity in India because of their durability. However it not only involves high initial cost but can also fail due to various reasons like day and night variations in warping stresses, seasonal changes in the modulus of sub-grade reaction etc. (Srinivas et. *al*., 2007). Although pre-cast concrete block pavement (Panda and Ghosh, 2002(a); Panda and Ghosh, 2002(b) and Ryntathiang, 2005) provides more flexible response (depending upon the dilantancy of the jointing sand) as compared to the normal concrete pavement mentioned above, There is a tendency for block movements under braking or accelerating force of the vehicular traffic and the interlocking caused by the jointing sand needs frequent maintenance which may not be practical for rural roads. As an alternative, for construction of sustainable rural roads with low life cycle cost and better riding quality, a new pavement technology called Plastic Cell filled Concrete Block Pavement (PCCBP) was developed in South Africa (Visser, 1994, 1999; Visser and Hall, 1999, 2003). In PCCBP, diamond shaped heat welded plastic cells (Figure 1) are used to encase concrete blocks. The cells are tensioned and spread across the foundation layer and concrete is filled and compacted into the cells. Upon compaction the cell walls get deformed resulting in interlocking of adjacent individual concrete blocks. In India, limited studies on PCCBP technology have been reported on the cost effectiveness and feasibility for rural roads. Lack of the above information has hindered the development of design standards, at least in the Indian road context.

The present work aims at the cost effectiveness (considering construction and maintenance cost for 5 years only) of flexible concrete block pavement over traditional flexible and rigid pavements is presented. A systematic field study to evaluate the layer moduli of PCCBP for various cell thicknesses over 100 mm thick water bound macadam (WBM) sub-base layer subjected to live traffic (low volume) conditions was carried out. Further in order to optimize the cost of pavement construction, an attempt is made to use stone dust (byproduct of aggregates crushing) in place of the traditional river sand. The layer moduli of PCCBP under live traffic condition was evaluated by using linear elastic layer theory based backcalculation computer code BACKGA (Reddy *et al.*, 2002) from the surface deflection data obtained through a custom fabricated Falling Weight Deflectometer (FWD). In the absence of design guidelines for PCCBP, rutting criteria as per IRC (2001) was adopted to design the PCCBP pavement. The reliability level of 50% was adopted considering 20 mm as the limiting value of rutting (Reddy and pandey, 1992). Conventional flexible and rigid pavements were design as per IRC (2007) and IRC (2004). Design parameters were adopted considering typical low volume rural roads in India (single lane road with 5% CBR and design traffic of 0.3 msa). The construction and maintenance cost were estimated based on Government of Assam schedule rate 2007-08 (PWD, 2007) and guidelines for the estimation of the maintenance cost for construction of the rural roads (IRC, 2002; PMGSY, 2010). Suitable cost escalation factor to bring to the year 2010 market rate were considered based on monthly wholesale price index (OEA, 2010).

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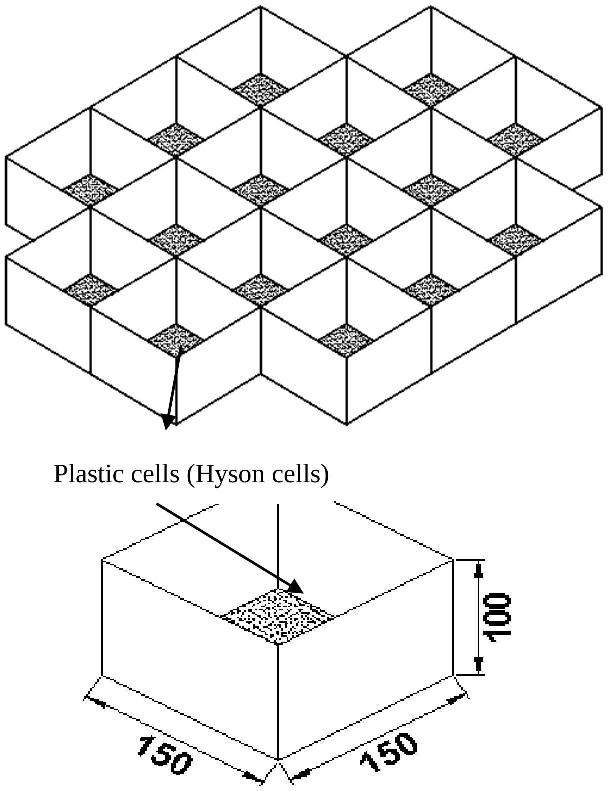

Fig. 1: Schematic diagram of typical plastic cells (Hyson cells) formwork with pocket size 150mm x 150mm x 100mm.

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II. CONSTRUCTION OF PCCBP TEST SECTIONS

A. *Test Section*

For the economic assessment of PCCBP over conventional flexible and concrete pavement for low volume roads, a full scale field study of different thicknesses of PCCBP over 100 mm WBM sub-base course was carried out at the National Highway, NH31(Yendrembam et. *al*., 2012, 2015). The road can be considered as a low volume road as the average daily traffic was estimated to be about 250-300 vehicles/day. Taking due care the problems of rain, the excavation of the existing bituminous pavement was done using an earth excavator in October, 2009. The upper layers of the existing pavement were removed and a trench measuring 15 m in length and 7 m in width and approximately 450 mm depth was excavated till sub-grade soil layer. The dry density and field moisture content of the sub-grade soil in place by core cutter method as per IS 2720 (1975) was found to be 1730 kg/m^3 and 13.80% respectively. The laboratory soaked CBR value obtained for the sub-grade soil collected from the excavated site was found to be 6% (IS 2720, 1987). The trench was backfilled with selected soil collected from nearby hill slope and the percentage field compaction was found to be ~98% of 100 mm thick WBM sub-base course as prescribed by the standard laboratory compaction value. In the present study MORTH (2001) was provided above the prepared sub-grade soil layer. After preparation of the WBM course, plastic cell formwork 5.5 m x 2.7 m for each test sections were laid, maintaining the cross fall (~ 2.5%) and longitudinal (~ 0.05%) slopes such that the new and the old pavement surfaces are in the same level. A gap of 750 mm on the edges and 300 mm (to provide space for tensioning plastic cells) between adjacent sections of PCCBP were left (Figure 2). A reusable wooden frame with hook arrangements was used for tensioning the plastic cell formwork. It also acts as side restrain for casting concrete. This wooden frame was to be removed after casting one section and for reusing it for another section. The plastic cell formwork, after tensioning forms diamond shaped (150 mm X 150 mm) pocket size (Figure-3a). From the laboratory test results, premix concrete with cement:stonedust:coarse aggregates ratio of ~1:1.25:2.0 by volume having 28-days cube compressive strength of ~32 MPa (Yendrembam et. *al*., 2012, 2015) was selected for casting PCCBP (Figure 3b).

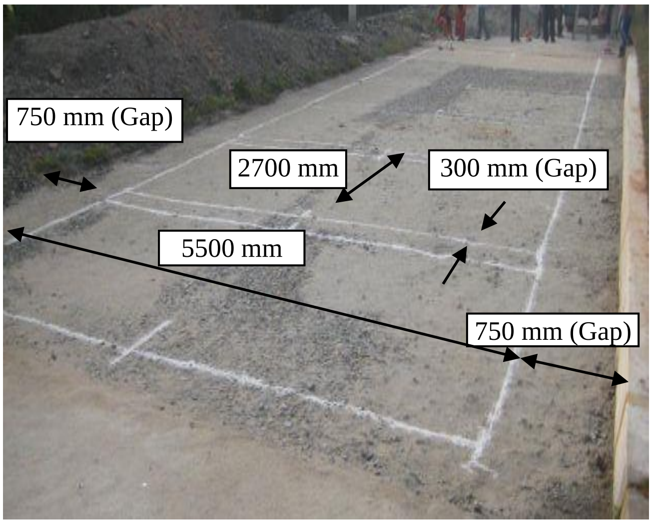

Fig. 2: Layout for different sections of PCCBP.

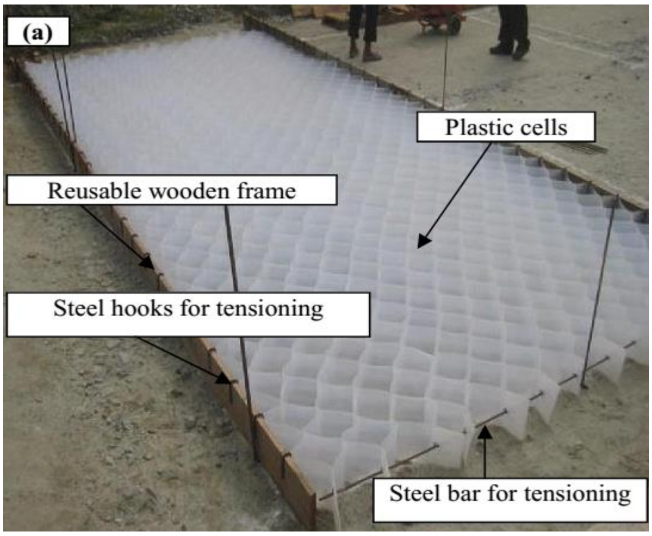

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Fig. 3 (a) Casting of the PCCBP and (b) Laying of plastic cell formwork for next PCCBP section.

B. Evaluation of PCCBP Layer Elastic Moduli

In this work, GA based BACKGA program developed by Reddy *et. al.*, (2002) was used for backcalculating the layer moduli of the PCCBP. In BACKGA a systematic search of the solution space defined by the ranges of moduli selected by the user is conducted. Detail explanation of the BACKGA technique is available in Reddy et al., (2002) and Rakesh *et al.*, (2006). The objective function of the BACKGA was to minimize the differences between the measured and the computed surface deflection of the pavement. Layer thickness, surface deflection, locations at which the deflections were measured, loading details and Poisson's ratios of the pavement were used as main inputs to the BACKGA program. Surface deflection data for various PCCBP test sections were recorded by Falling Weight Deflectometer (FWD). For each test section the load was dropped 3-4 times and surface deflection data were collected on either side of the load plate at radial distances of -500 mm, -300 mm, 0 (zero), 300 mm, 600 mm, 900 mm and 1200 mm. The surface deflections were then normalized to a load of 40 kN (IRC, 2007) and average of three deflection readings were taken for calculation of layer elastic modulus through BACKGA. The validation of the layer elastic modulus obtained through BACKGA program was done using two different layer elastic analyses based computer program code KENLAYER (Huang, 2010) and Finite Element (FE) analysis based ABAQUS software (ABAQUS, 2009). A comparison of surface deflections of PCCBP (100 mm thickness) with those obtained from the literature on similar studies *viz.*, Roy *et. al.*, (2009) and Ryntathiang *et. al.*, (2005). The PCCBP layer elastic moduli increases with increase in PCCBP thickness, an increase of ~90% in elastic modulus from 1958 MPa (for 50 mm PCCBP thickness) when the thickness is increased from 50 mm to 150 mm (i.e. 200% increase in thickness). In the present study, design analysis has been carried out for 100 mm thick PCCBP laid over 100 mm thick WBM course of sub-base layer. The layer elastic modulus of PCCBP obtained through BACKGA was 2300 MPa. (Yendrembam et. *al.*, 2012, 2015). Following IRC (2001) and IRC (2007) the traffic volume survey and the axle load survey was carried out on the PCCBP test sections. It has been observed that the cumulative ESAL repetitions for ~11 months from the day of initial opening to the normal traffic is approximately 62,000 which is equivalent to ~25 years of service for a typical rural road in India. Figure 4a. shows the view of the test sections at the time of initial opening to the normal traffic in October, 2009. Almost 5 heavy monsoon had passed, the PCCBP test sections over 100 mm thick WBM sub-base course has shown a good performance. Routine maintenance after 5 years of service was carried out and resurfacing with a thin coat of 50 mm thick bituminous carpet was done in October, 2014. Figure 4b. shows the bituminous resurfaced view of the PCCBP test sections.

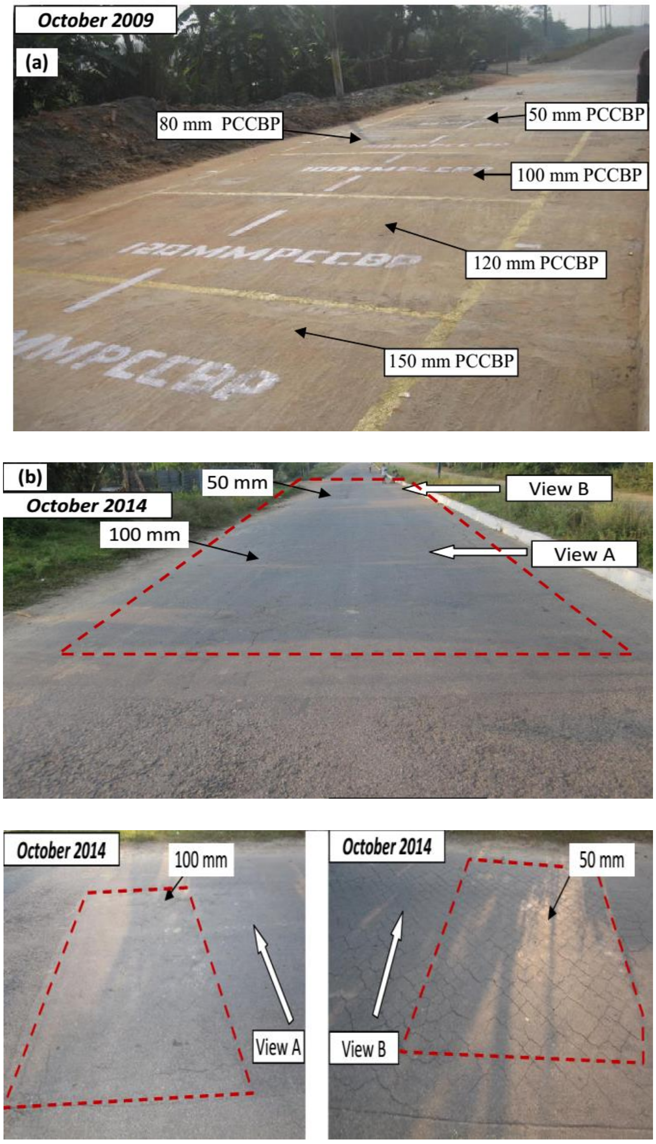

Fig. 4: (a) PCCBP test section at the time of initial opening the traffic on Oct 2009 and (b) Bituminous resurfaced PCCBP test section with thin coat of 50 mm bituminous carpet after 5 years on Oct 2014.

III. DESIGN OF DIFFERENT TYPES OF PAVEMENT

A. Design Parameters

In order to assess the economic advantage of PCCBP (using stone dust as 100% sand replacement in concrete) over conventional flexible and rigid (concrete) pavements cost comparison have been carried out considering both construction and maintenance costs for a period of 5 years.

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To demonstrate the cost analysis, similar design parameters adopted elsewhere (e.g., Roy *et al*., 2009, 2010, Ryntathiang, 2005) are considered:

1. Lane width = 3.75 m (single lane carriageway)
2. Sub-grade CBR = 5%
3. Design traffic = 300,000 standard axle load repetitions

B. Design of Flexible Pavement

The flexible pavement has been design as per IRC (2007) for the design parameters mentioned in Section 5.2.1. From the pavement design chart, Figure 4 of IRC (2007), the thicknesses of the pavement layers have been obtained as 150 mm thick granular sub-base course (CBR > 20%), 175 mm thick WBM course and 20 mm thick bituminous premix carpet as surfacing.

C. Design of Rigid Pavement

The rigid pavement has been designed for a wheel load of 51 kN (legal limit for axle load is 102 kN) as per IRC (2004) for the design parameters mentioned in Section 5.2.1. The effective modulus (*k*) of sub-grade reactions (20% increased for providing 150 mm sub-base course) for 5% CBR value for sub-grade is 50.4 X10^{-3} N/mm^2/mm as per IRC (2004).

Flexural strength of concrete:

Adopt a 28 day compressive strength of 30 MPa (f_c)

Flexural strength, $f_t = 0.7\sqrt{fc} = 3.834$ MPa

Therefore,
the 90 day flexural strength = 1.20 x 3.834 = 4.6 MPa.

Design thickness check

Edge load stress

As per IRC (2004), the design thickness of pavement slab is 220 mm, and the corresponding edge stress is 2.35 MPa (for k = 50.4 X10^{-3} N/mm^2/mm).

Temperature stress

The radius of relative stiffness (*l*) for 220 mm thick slab as per IRC (2004) = 857.36 mm.
Assuming a contraction joint spacing of 3.75 m and width of slab as 3.75 m, the edge temperature stress was calculated to be 1.35 MPa (Table 4 of IRC, 2004 for Assam state).

Total stress

The total stress = edge stress + temperature stress = 3.7 MPa, which is less than 4.6 MPa (flexural strength of the concrete). Hence, the slab thickness is safe and can be adopted.

D. Design of PCCBP

Based on the past studies carried out on PCCBP by different researchers, the interlocking of the individual blocks in PCCBP allows a limited rotation and the pavement acts as a flexible concrete pavement (Visser, 1994). Also considering the observation on the present full scale field study that PCCBP has considerably high modulus, it is unlikely to suffer significant permanent deformation. Hence, only WBM (sub-base) and sub-grade are anticipated to undergo rutting i.e., rutting may be the mode of failure in this type of pavement as observed by Ryntathiang *et. al.*, (2005) and Roy *et. al.*, (2010). Rutting along the wheel path may be caused by permanent deformation in the sub-grade and/or sub-base of the pavement. Surface rutting in the flexible pavement is generally controlled by limiting the vertical sub-grade strain. Indian Road Congress (IRC, 2001), Shell and Asphalt Institute (SHELL, 1978) have limiting sub-grade strain criteria for controlling rutting in flexible pavements. While rutting in the asphalt layer is controlled by selection of a binder, the rutting in granular as well as in the sub-grade is controlled by limiting the vertical sub-grade strain. In the present study a reliability level of 50% (AASHTO, 1993) is adopted for design of PCCBP. Reddy and Pandey (1992) proposed the following vertical sub-grade strain criterion for 50% reliability considering 20 mm as the limiting value of rutting.

$$N = 3.0599 \times 10^{-8} [1/\epsilon_z]^{4.5337} \quad (3.1)$$

Where, N = Number of cumulative standard axles to produce rutting of 20 mm

ϵ_z = Vertical sub-grade strain (micro strain)

The elastic modulus of the sub-grade soil ($E_{sub\text{-}grade}$) and sub-base layer ($E_{sub\text{-}base}$) can be obtained from:

$$E_{sub\text{-}grade} = 10 \times CBR \quad \text{for } CBR \leq 5 \quad (3.2)$$
$$= 17.6 \times (CBR)^{0.64} \quad \text{for } CBR > 5 \text{ and}$$

$$E_{sub\text{-}base} = E_{sub\text{-}grade} \times 0.2 \times h^{0.45} \quad (3.3)$$

For the present study, design analysis has been carried out for 100 mm thick PCCBP laid over a sub-base layer of 100 mm thick WBM course. The elastic layer modulus of 2300 MPa for PCCBP layer obtained through BACKGA has been used. The layer modulus of sub-grade and sub-base has been calculated as, $E_{sub\text{-}grade}$ = 50 MPa (i.e. 10 x 5 for CBR 5%) and $E_{sub\text{-}base}$= 50 x 0.2 x $(100)^{0.45}$ = 79.43 MPa. Using computer program code KENLAYER (Huang, 2010), the vertical sub-grade strain is calculated to be 1.832 x 10^{-3} MPa, which is lesser than allowable strain value of 2.3 x 10^{-3} mm. The design thicknesses of the different types of pavements for the cost comparison are shown in Table I.

Table I Design thickness of flexible, rigid and PCCBP pavement for cost comparison

Type of Pavement	Design thickness
Flexible	20 mm Pre-mix Carpet 175 mm thick WBM course 150 mm thick granular sub-base course
Rigid	220 mm thick concrete slab 150 mm thick WBM base course
PCCBP	100 mm thick Plastic Cell Filled Concrete Block Pavement 100 mm thick WBM base course

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IV. COST COMPARISON

A. *Construction and Maintenance Cost*

The construction and maintenance cost have been estimated based on Public Works Department, Government of Assam schedule rates 2007-08 (PWD, 2007) and the guidelines for the estimation of the maintenance cost for construction of the rural roads (IRC, 2002; PMGSY, 2010). Suitable cost escalation factor to bring to the year 2010 market rate was considered based on monthly wholesale price index (OEA, 2010). In the absence of guidelines on maintenance cost for PCCBP and considering the good performance of cell filled concrete pavement 100 mm thick over 100 mm compacted WBM sub-base course which withstood 5 (five) heavy monsoons without any maintenance, it is considered to be the same as that taken for concrete pavement. The cost calculation for economic evaluation of PCCBP vis-a-vis conventional flexible and rigid pavement is given below. The details of cost analysis is enclosed as **Appendix**.

B. *Cost Estimation*

*i. **Flexible pavement***

1. Construction of 150 mm thick granular sub-base course = Rs 169/m^2
2. Providing and laying 175 mm WBM course = Rs 237/m^2
3. Construction of 20 mm thick premix carpet (Grade A seal coat) = Rs 201/m^2
4. Add cost escalation factor to bring to present (year 2010) rate = Rs 89/ m^2

Therefore, the total cost of construction for flexible pavement = Rs 696/ m^2
The routine maintenance cost for 5years = Rs 46/ m^2
Renewal cost of flexible pavement after 5 years =Rs236/ m^2

*ii) **Rigid pavement***

1. Construction of 150 mm WBM base course = Rs 203/m^2
2. Construction of 220 mm thick plain cement concrete slab =Rs 1193/m^2
3. Add cost escalation factor to bring to the present (year 2010) rate = Rs 205/m^2

Therefore, the total cost of construction for rigid pavement = Rs 1601/m^2
The routine maintenance cost for 5years = Rs 16/m^2
Renewal / major repair cost of rigid pavement after 5 years = Rs 26/ m^2

*iii) **Plastic cell filled concrete block pavement (PCCBP)***

1. Cost of construction for 100 mm thick WBM course = Rs 135/ m^2
2. Cost of plastic cell formwork (prepared from plastic pipe) = Rs 120/ m^2
3. Cost of construction for 100 mm thick cement concrete (using stone dust) = Rs 384/ m^2

Therefore, the total cost of construction for PCCBP pavement = Rs 639/ m^2
The routine maintenance cost for 5years = Rs 16/ m^2
Renewal / major repair cost of PCCBP pavement after 5 years = Rs 26/ m^2.

V. DISCUSSIONS

The cost comparison of PCCBP vis-à-vis conventional flexible and concrete pavement considering both construction and maintenance costs is shown in Fig. 5.

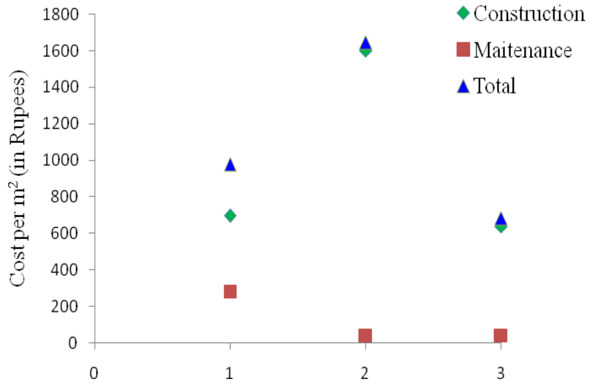

Fig. 5 Cost comparison of flexible, rigid and PCCBP pavements (for 5 years).

It can be observed from Figure 5 that initial construction cost for both flexible and rigid pavements are higher than that of PCCBP by ~9% and ~150% respectively and the total cost (including maintenance cost for 5 years) of flexible and rigid pavements are higher by ~43% and ~141% respectively as compared to that of PCCBP. The present results are in agreement with study conducted by Roy *et al.*, (2009, 2010), in Kharagpur (using river sand as fine aggregates), where the total cost (for 5 years) of flexible and rigid pavements are reported to be higher by ~54% and ~131% respectively as compared to that of PCCBP. The economical competitiveness of PCCBP over conventional pavements *viz.*, flexible (Visser, 1994; Visser and Hall, 1999, 2003; Sahoo *et al.*, 2006), rigid (Roy *et al.*, 2009, 2010) and block (Visser, 1994; Visser and Hall, 1999; Ryntathiang, 2005) pavements have also been reported in the literature. Further considering negligible or no maintenance requirement of PCCBP tested for 4, 5 and 8 years by Visser and Hall (1999), Roy *et al.*, (2009) and Visser and Hall (2003) respectively, cost saving in using PCCBP is likely to be increased. Hence PCCBP with waste stone dust as replacement for the traditional sand for both concrete and WBM can be an economical option for rural roads. Any distresses that are accrued after 15 years of service may be rectified to bring back to the normal riding quality using an overlay of 50 mm PCCBP (Roy *et. al.*, 2009).

VI. CONCLUSIONS

1. As compared to PCCBP, the initial construction costs for conventional flexible and rigid pavement are seen to be higher by 9% and 150% respectively.
2. The total cost including construction and maintenance cost for 5 years of flexible and rigid pavements are higher by 43% and 141% respectively as compared to that of PCCBP.

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3. Cent percent replacement of river sand in concrete by stone dust proved to be cost cutting without significant change in the strength of the concrete. Hence, PCCBP can be a suitable alternative to the conventional flexible and concrete pavement for the construction of rural roads which is labour intensive and cost effective.

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APPENDIX

I. Abstract of cost

Flexible pavement (PWD, 2007 and OEA, 2010)

Sl. no.	Particulars	Quantity	Unit	Rate (in Rs)	Amount (in Rs)
1.	Providing and applying primer coat with bitumen emulsion on prepared surface of granular base including cleaning of road surface and spraying primer at the rate of 1.00 kg/ m^2 using mechanical means	3750.00	m^2	37.00	138750.00
2.	Providing and applying tack coat with emulsion using emulsion pressure distributor at the rate of 0.20 kg/ m^2 on the prepared bituminous / granular surface cleaned with mechanical broom.	3750.00	m^2	13.00	48750.00
3.	Providing, laying and rolling of open- graded premix surfacing of 20 mm thickness composed of 13.2 mm to 5.6 mm aggregate either using penetration grade bitumen (60/70) or bitumen emulsion to required line, grade and level to serve as wearing course on a previously prepared base, including mixing in a suitable plant laying and rolling with a smooth wheeled roller 8-10 tonnes capacity to the required level and grade (including carriage up to initial lead of 5.0 km from quarry and carriage of mixed materials up to 10.0 km initial lead from mixing plant)	3750.00	m^2	104.00	390000.00
4.	Providing and laying seal coat sealing the voids in bituminous surface laid to the specified levels, grade and cross fall using Type A seal coat (including carriage up to initial lead of 5.0 km from quarry)	3750.00	m^2	47.00	176250.00
5.	Providing, laying, spreading and compacting stone aggregates of specific sizes to water bound macadam specification including spreading in uniform thickness, hand packing, rolling with vibratory roller 8-10 tonnes in stages to proper grade and camber, applying and booming requisite types of screening / binding material to fill up the interstices of coarse aggregates, watering and compacting to the required density (with an initial lead of 5.0 km).	656.25	m^3	1353.0 0	887568.00
6.	Construction of granular sub-base by providing coarse graded materials, spreading in uniform layers with motor grader on prepared surface, mixing by mix in place method with rotavator at OMC and compacting with vibratory roller to achieve the desired density, complete as per clause- 401 (with an initial lead of 5.0 km)	562.50	m^3	1127.0 0	633937.50
	Total Add 14.67 % cost index to bring to the present market rate Grand Total (for 3750 m^2 of flexible pavement)				2275255.0 (+) 333779.90 2609035.0
	Therefore, the cost of flexible pavement per m^2				695.70 = ~ 696.00

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II. Abstract of cost

Rigid pavement (PWD, 2007 and OEA, 2010)

Sl. no.	Particulars	Quantity	Unit	Rate (in Rs)	Amount (in Rs)
1.	Construction of un-reinforced, dowel jointed, plain cement concrete pavement over a prepared sub-base with 43-grade cement @ 400 kg/ m^3, coarse and fine aggregates conforming to IS-383, maximum size of coarse aggregates not exceeding 25mm, mixed in a batching and mixing plant as per approved mixed design, transported to the site, laid with a fixed form or slip form paver, spread, compacted and finished in a continuous operation including provision of contraction, expansion, construction and longitudinal joints, joint filler, separation member, sealant primer, sealant joint, deboning strips dowel bar, tie rods, admixture as approved, curing compound, finished to lines and grades as per drawing (including carriage of mixed materials up to 10.0 km initial lead from mixing plant.)	825.00	m^3	5422.00	4473150.00
2.	Providing, laying, spreading and compacting stone aggregates of specific sizes to water bound macadam specification including spreading in uniform thickness, hand packing, rolling with vibratory roller 8-10 tonnes in stages to proper grade and camber, applying and brooming requisite types of screening / binding material to fill up the interstices of coarse aggregates, watering and compacting to the required density (with an initial lead of 5.0 km)	562.50	m^3	1353.00	761062.50
	Total Add 14.67% cost index to bring to the present market rate Grand Total (for 3750 m^2 of rigid pavement)				5234212.50 767858.97 6002071.47
	Therefore, cost of rigid pavement per m^2				1600.55 = ~ 1601.00

III. Abstract of cost

Plastic Cell Filled Concrete Block Pavement (PCCBP) based on present (year 2010) market rate of Assam state.

A. Cost of plastic

Total plastic required for making plastic cell formwork of (150 mm x 150 mm x 100 mm) for an area of 2.7 x 5.5 = 14.85 m^2 is 2/3 of two rolls of plastic weighing 12.00 kg each.

Cost of plastic per roll (12.00Kg) @ Rs 95 per kg (12 x 95) = Rs 1140.00
Therefore, cost of plastic for 14.85 m^2 (2/3 x 2 x 1140) = Rs 1520.00
Therefore, cost of plastic for 3750 m^2 (3.75 x 1000) = Rs 383838.38
Add 5% extra as transportation charges = Rs 19191.19
Total cost of plastic 3750 Sqm area = Rs 403029.57

B. Man-days required

Time taken to cutting and sealing one stripe of plastic (8 m) = 60 minutes
Number of stripes required for 14.85 m^2 (2.7 m x 5.5 m) area = 15 stripes
Time taken for cutting and sealing plastic for 14.85Sqm area (15X60) = 16 hours

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Therefore, time taken for 3750 Sqm area (3.75X1000)	= 4040.4 hours
Number of man-days required (assuming eight hours working per day)	= 505.00 man-days
Assuming cost of man-days @ Rs 80 per day (80X505)	= Rs 40400.00

C. *Paddle Sealing Machine*

Cost of electrically operated paddle sealing machine	= Rs 10000.00
Therefore, total cost for preparation of plastic cell formwork for 3750Sqm area,	
(403029.57 + 40400.00 + 10000.00)	= Rs 453029.57
Therefore, cost of plastic cell formwork for one Sqm area	= Rs 120.80
(Say)	= Rs 120.00

D. *Cost of Concreting*

Volume of concrete for 100 mm thick PCCBP (3.75 X1000X0.1)	= 375 m^3
Cement (50 Kg/bag) required for 1 m^3 of concrete (1:1.25:3)	= 9.87 bags
Cement required for 375 m^3 of concrete	= 3701.25 bags
Cost of cement @ 230 per bag (230 X 3701.25)	= Rs 851287.50
Coarse aggregates required for 1 m^3 of concrete (1:1.25:3)	= 0.91 m^3
Coarse aggregates required for 375 m^3 of concrete (1:1.25:3)	= 341.33 m^3
Cost of coarse aggregates @ Rs 900/ m^3 (900 X 341.33)	= Rs 307197.00
Stone dust required for 1 m^3 of concrete (1:1.25:3)	= 0.455 m^3
Stone dust required for 375 m^3 of concrete (1:1.25:3)	= 170.66 m^3
Cost of stone dust @ Rs 200/ m^3 (200X170.66)	= Rs 34133.33
Total cost (8, 51,287.50 +3, 07,197.00 +34,133.33)	= Rs 1192617.83
Add 5% transportation charges	= Rs 59630.89
Grand total cost of concrete for 3750 Sqm area	= Rs 1252248.72
Therefore, cost of concrete per Sqm area	= Rs 333.93
Again, cost of laying and concreting 126 Sqm (18mX7m)	= Rs 6300.00
Cost of laying and concreting per Sqm area of PCCBP	= Rs 50.00
Therefore, total cost (including material cost) for concreting per Sqm	= Rs 383.93
(Say)	= Rs 384

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