Block Pavement

Name

[Institutional Affiliation(s)]

Author Note

Abstract

Research in the field of construction have utilized various tests to identify the most suitable materials for the construction of block pavement. It has been observed that various synthetic materials for the building or pavement blocks are recently used. Keeping in view the environmental issues and rising greenhouse effects, it is suggested by the studies performed to use those synthetic materials that are eco-friendly to build block pavement. Based on the experiments performed different results have been analyzed including the study methods utilizing the mix ingredients for the construction are preferably more suitable for the production of block pavements. Review of literature has evaluated that previous studies performed to test alkali-activation procedure was positive correlated with this study conducted (Hein & Burak, 2007). It is a common practice and observation that pedestrian tend to adapt a path that is more comfortable and more clean and leave the path which is uncomfortable. These issues can be resolved by incorporating the use of an adequate system of maintenance management. Presence of different aggravates and components are fundamentally helpful in producing mechanically strong and tensile block pavement.

*Key words*: Block Pavement, synthetic materials, constructing blocks, tensile block pavement

Transportation Research Board

The construction of block pavements is not always required to make on straight and easy paths instead often engineers and constructors have to work on slopes and irregular land patches to make block pavements. Traffic acceleration and braking are major problematic factors in this regard as they increase the exerted horizontal force on the path (Hein & Burak, 2007). The block’s compressive strength is inversely affected conditional to the w/c ratio and the concentration of cement. Compressive strength and better dry density can be achieved if the content of the cement is added in increased concentration relative to that of optimum water in concrete mixture (Jamshidi et al., 2019). A study was carried out to understand the pedestrian distress and calculate/measure the exact statistical situation of the road or pavement and to standardize the results. The authors of research adopted a standardized approach called PCI (Pavement Condition Index) to analyze and judge the condition of the road or pavement according to defined rules (Lin, Cho, & Kim, 2016). They are often responsible for creating opened joints at the top of the toad section due to the horizontal creep of the blocks throughout the slope (Lin et al., 2017). According to recent studies, paving blocks are prepared from cement constructive materials and Portland cement is under examination to be used as environmental friendly material to produce block pavements (Ahn, Marcaida, Lee, & Jung, 2018). Studies have shown that emission of greenhouse gases have produced global warming therefore, policies are redefined by the government for the industries to use eco-friendly materials for production (Jamshidi et al., 2019). With the emission of carbon dioxide and greenhouse gases, industries are more focused to use eco-friendly materials for the production of industrial products.

# Review of Literature

In this section, literature reviews of several national and international papers are on the different aspects and factors of the block pavements used in parking areas, market places or for traffic are provided (Lin et al., 2016). We will analyze the literature reviews separately from the perspective of design, construction and performance of block pavements respectively.

## Design of Block pavements

The first study is about the impact of PICP (permeable interlocking concrete pavement) design on the performance and different other aspects of block on service life of the road. The results are confirmed using a special instrument ‘infiltration meter’ that is used to measure the capacity of infiltration and give immediate results with no disturbance. Results of research are observed after reviewing many places and sites of different ages and an approximate correlation is developed after determining the reduction in the surface infiltration (Zoccali et al., 2018). The performance of infiltration depends on permeability of the aggregates and opening ratio and determine reliable operand for the efficiency up to 8 to 12 years (Borgwardt, 2015).

The mechanical characteristics of the blocks including larger size and rabbet joint’s elastic co-efficient effect the performance and endurance of the pavement. According to a study, increment in the size of blocks from 30 cm×20 cm to 50 cm×30 cm, the deflection of pavement decreases from 25% to 30%. Also, when the rabbet joint’s coefficient of elasticity increases from 102 Newton/meter to 108, pavement defection decreases by 505 to 55%. In designing pavement, the traffic condition of the road or pavement is important to observe in order to determine the level of stain at the top of subgrade (Shan et al., 2015).

### Construction of Block Pavement

There are a number of researches and thesis of national and international scholars regarding the construction of blocks and block pavements. We will try to explore a few of them in the literature review. The use of nylon fiber in the construction of block pavement is studied in 2015 by (Neekhra et al.,2015). The studies and experiment concluded that to evaluate the strength of block nylon can be effectively used. It is basically a thermoplastic polymer is considered as among high tenacity fibers. Addition of nylon with cement is observed to add strength of the paver block. After mixing it with varying concentration, it was concluded that if the addition of 0.3% of nylon with the specific percentage of cement into concrete will result in increasing the strength in 7, 14 and sometimes 21 days of age. (Reddy, 2015) also studied the concentration of nylon in the construction of blocks and carries out research to find the answers. He studied that for a good compression strength concrete block is mixed with risk husk and nylon fiber (Lin et al., 2016). Maximum strength of the concrete block can be achieved by mixing 0.3% of nylon and 20% of risk husk.

According a study, the block’s compressive strength is differently affected depending upon the w/c ratio and the concentration of cement. Compressive strength and relatively better dry density can be achieved if the content of the cement is added in increased concentration relative to that of optimum water in concrete mixture. Result of the studies showed that level of design strength ranging from 20-33 MPa and 31-42 MPa was observed and achieved by using the cement content of 12 % with w/c ratio from 0.50-0.70 and using cement content of 15% by using 0.45-0.65 w/c ratio(Ling, Nor, & Mudiyomo, 2006). In a study, it was noticed that for roads and footpaths, concrete blocks are very useful, easy laying have better look and impact value of good resist. It uses rubber pads and add different percentages of steel aggregates in blocks and increase the strength of ordinary blocks by 50%. Also it was found that filling the spaces between blocks with jointing sand is very helpful in reducing the deflection of block concrete pavement and to distribute the load evenly and to make a balance and firm ground (Yeole & Varma, 2014).

When we talk about better roads and pavements, we consider comfort as a major requirement while planning and managing facilities for pedestrians. It is a common practice and observation that pedestrian tend to adapt a path that is more comfortable and more clean and leave the path which is uncomfortable. These issues can be resolved by incorporating the use of an adequate system of maintenance management. A study was carried out to understand the pedestrian distress and calculate/measure the exact statistical situation of the road or pavement and to standardize the results. The authors of research adopted a standardized approach called PCI (Pavement Condition Index) to analyze and judge the condition of the road or pavement according to defined rules. The survey carried out in Italy and based on the idea of research several roads and pavements were considered unsafe based on the level of distress (Corazza, Mascio, & Moretti, 2016). According to PCI method, the level of distress was identified by diffused cracking, potholes, corrugation, weathering, bleeding, block cracking, linear cracking, and raveling, deformation because of run-off water and deformation because of roots. Also edge disruptions, depressions, and issues related to differential settlement of the path in contrast to interspace of buildings.

#### Performance of Block Pavement

The construction of block pavements is not always required to make on straight and easy paths instead often engineers and constructors have to work on slopes and irregular land patches to make block pavements. Traffic acceleration and braking are major problematic factors in this regard as they increase the exerted horizontal force on the path. They are often responsible for creating opened joints at the top of the toad section due to the horizontal creep of the blocks throughout the slope.

Pavement block are the most popular blocks solution for urban surfaces. Different variety of products are used to build pavement blocks. Depending upon the skid resistance and interlocking concrete are the most advanced technology used nowadays. Different by-products and waste products such as second hand materials are used to generate pavement blocks. Different synthetic materials are used to prepare paving blocks. Various studies have been conducted to test synthetic materials for the building or pavement blocks. Different tests have highlighted positive results and that need to be optimized for further laboratory testing.

CBP (Concrete Block Pavement) was first introduced in early 1950’s as a replacement of clay bricks in Netherlands. The idea then spread into the world as the design and the endurance of these blocks to be used for construction of pavements, roads and different kind of pathways. The durability, strength and pleasing aesthetic look of the blocks has made it very important and ideal for many industrial application, municipal and commercial purposes. Many countries including, UK, The United States, The Netherlands, Canada, Australia, Argentina and many others are carrying out a lot of research and publications in this regard for the past 50 years or so. The purpose of these research activities are to bring about refinement and development of Concrete Block Pavement ie CBP. Modular pavements Block are the kind of structures composed of pavers of concrete and brick which are utilized throughout the world successful. These are often used in the world for low volume. The use of these kind of pavements are changed in past few decades where they are now being used to manufacture or construct path for the cycles, pedestrian path, driveway for the residences, historical centers, and industrial areas. The modular pavements prove that are very useful from economic and good performances and both technically. Talking about their performance from historical point of view, historic towns and neighborhood are often used because of their environmental and architectural impact, low maintenance and durability provided if the design requirements are fulfilled during their construction. The design of the blocks is a very fundamental issue and design loads must be quantified carefully. Quantization of the design load must be performed with care and caution because even if the design of the blocks have to deal with stone pavements for pedestrian areas and sidewalks.

According to recent studies, paving blocks are prepared from cement constructive materials and Portland cement is under examination to be used as environmental friendly material to produce block pavements. Studies have shown that emission of greenhouse gases have produced global warming therefore, policies are redefined by the government for the industries to use eco-friendly materials for production. With the emission of carbon dioxide and greenhouse gases, industries are more focused to use eco-friendly materials for the production of industrial products. Study performed by Piergiogio Tataranni has shown that the presence of aggregates within the paving block is fundamental in order to achieve the tensile splitting strength required by the EN 1338 standard. As a downside, the addition of particles within the AA paste slightly reduces the workability and casting operations and limits the full adhesion of the mortar to the mold profile (Ahn et al., 2018). Emphasis is diverted towards second hand materials to be used to prepare pavement blocks (Ahn et al., 2018). Relatively less studies have been conducted to use second hand material to produce pavement blocks however, several applications and procedures are introduced in the market. Research is essentially needed in the relative construction industries to check and test the efficacy of the second hand materials to be used for the production of pavement blocks.

The study was carried out in order to investigate the effect of several parameters including laying pattern, width, joint, and also on the thickness of the paving joint. In the methodology, different patterns of lying were used. The responses from the pavements are characterized in term of deflection and horizontal creep due to the application of immense load. The results of the study indicated that laying pattern of herringbone 45 degrees and joint width of 3mm performs best slopes (Tataranni, 2019). According to the study, thickness of 100 mm is more stable and reliable as compared to the thickness of 60mm from aspect horizontal resistant force. Also, the results of the study indicated that the slope of the horizontal creep is increased as the increase of scope increases (Hengl et.al, 2018).

**Materials and Methods**

Different experimental studies were taken to review the literature and to evaluate constituents and materials used for the production of block pavements. Experimentally performed study was observed in which a pavement block entirely generated by using alkali-activated waste basalt powder (Tataranni, 2019). Second study was performed using synthetic paste in a specific grading distribution. The properties and composition of the materials were tested and experiments were performed. Mechanical properties of components were tested using different distribution at different grades. In this study precursor such as basalt powder, metakaolin were used at specific design (Tataranni, 2019). Activators such as sodium silicate and sodium hydroxide were used (Tataranni, 2019). These materials were used to increase the performance of the synthetic materials used for pavement blocks.

**Study Design**

Research plan was divided into two stages. In first stage, alkali activated paste was characterized and in second step, experimental laboratory characterization was performed. Evaluation of the materials were performed utilizing different tests that were specifically related to mechanical properties of the components (Tataranni, 2019).

**Analysis**

Analysis of the experiments were performed using mechanical procedures such as compressive strength analysis and was compared with the standard traditional reference such as hard mortar. In the sample, tests performed were shape and dimensions, tensile strength, water absorption characteristic, abrasive resistance and slip resistance (Tataranni, 2019). The data collected was classified and results were generated on the basis of experimentally suitable material for production of pavement blocks.

**Conclusion**

Pavement block are the most popular blocks solution for urban surfaces. Different variety of products are used to build pavement blocks. Depending upon the skid resistance and interlocking concrete are the most advanced technology used nowadays (Tataranni, 2019). Depending upon the skid resistance and interlocking concrete are the most advanced technology used nowadays. Different by-products and waste products such as second hand materials are used to generate pavement blocks. Different synthetic materials are used to prepare paving blocks (Lin et al., 2017). Various studies have been conducted to test synthetic materials for the building or pavement blocks. Considering the environmental issues and rising greenhouse effects globally, it is recommended by the studies performed to use those synthetic materials that are eco-friendly to construct block pavement (Ahn et al., 2018). Based on the experiments performed different results have been analyzed including the study methods utilizing the mix ingredients for the construction are preferably more suitable for the production of block pavements. The use of synthetic kind of pavements are changed in past few decades where they are now being used to manufacture or construct path for the cycles, pedestrian path, driveway for the residences, historical centers, and industrial areas (Lin et al., 2017). Review of literature has evaluated that previous studies performed to test alkali-activation procedure was positive correlated with this study conducted. Presence of different aggravates and components are fundamentally helpful in producing mechanically strong and tensile block pavement.

**References**

Ahn, J., Marcaida, A., Lee, Y., & Jung, J. (2018). Development of Test Equipment for Evaluating Hydraulic Conductivity of Permeable Block Pavements. *Sustainability*, *10*(7), 2549.

Hein, D., & Burak, R. (2007). Development of a pavement condition rating procedure for interlocking concrete pavements. *Prepared for Session of Cost-Effective Assessment Rehabilitation of the Condition of Materials for Transportation Association of Canada Fall 2007 Meeting, Saskatoon, Saskatchewan*.

Jamshidi, A., Kurumisawa, K., White, G., Nishizawa, T., Igarashi, T., Nawa, T., & Mao, J. (2019). State-of-the-art of interlocking concrete block pavement technology in Japan as a post-modern pavement. *Construction and Building Materials*, *200*, 713–755.

Lin, W., Cho, Y., & Kim, I. T. (2016). Development of deflection prediction model for concrete block pavement considering the block shapes and construction patterns. *Advances in Materials Science and Engineering*, *2016*.

Lin, W., Kim, D., Ryu, S., Hao, H., Ge, Y.-E., & Cho, Y.-H. (2017). Evaluation of the Load Dissipation Behavior of Concrete Block Pavements with Various Block Shapes and Construction Patterns. *Journal of Materials in Civil Engineering*, *30*(2), 04017291.

Tataranni, P. (2019). Recycled Waste Powders for Alkali-Activated Paving Blocks for Urban Pavements: A Full Laboratory Characterization. *Infrastructures*, *4*(4), 73.

Borgwardt, S. (2015). In-Situ Infiltration Performance of Permeable Concrete Block Pavement–New Results. In *Proceedings of the 11th International Conference on Concrete Block Paving September* (pp. 9-11).

Shan, J. S., Li, H., & Jiang, H. W. (2015). Mechanical characteristics and design method of interlocking concrete block pavement. *Journal of Traffic and Transportation Engineering*, *15*(4), 9-17.

Neekhra, R., Raja Rawat, and Vishal Gupta. "Compressive Strength of Paver Block by Adding Nylon Fiber." *International Journal for Scientific Research & Development, ISSN (online)* (2015): 2321-0613.

Reddy, A., Gupta, V., & Garg, D. Effect of Partial Replacement of Cement by Rice Husk Ash Using Nylon Fiber in Concrete Paver Block. *IJSRD-International Journal for Scientific Research & Development, ISSN (online)*, 2321-0613.

Ling, T. C., Nor, H. M., & Mudiyono, R. (2006, July). The Effect of Cement and Water Cement Ratio on Concrete Paving Block. In *1st Regional Postgraduate Conference on Engineering and Science*.

Yeole, R. C., & Varma, M. B. (2014). Comparison of mix designs of paver blocks using waste rounded Steel Aggregates and Rubber Pad. *International Journal of Emerging Technology and Advanced Engineering*, 2250-2459.

Corazza, M. V., Di Mascio, P., & Moretti, L. (2016). Managing sidewalk pavement maintenance: A case study to increase pedestrian safety. *Journal of Traffic and Transportation Engineering (English Edition)*, *3*(3), 203-214.

Hengl, H. L., Kluger-Eigl, W., Lukacevic, M., Blab, R., & Füssl, J. (2018). Horizontal deformation resistance of paving block superstructures–Influence of paving block type, laying pattern, and joint behaviour. International Journal of Pavement Research and Technology