WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

MECHANICAL PROPERTIES OF TWO-LIFT CONCRETE MADE USING DEMOLISHED RECYCLED COARSE AGGREGATE

***Ronak Sethi*[*1], *Ashish Kumar*[*2], *Swetank Kumar*[*3], *Utkarsh Anand*[*4], *Reshma E. K.*[*5]**

[*1,2,3,4]*Student, Department Of Civil Engineering, Dayananda Sagar College Of Engineering, Bengaluru 560078, India.*
[*5]*Assistant Professor, Department Of Civil Engineering, Dayananda Sagar College Of Engineering, Bengaluru 560078, India.*

A B S T R A C T

Two-lift concrete paving (2LCP) involves placing two layers of concrete (wet-on-wet) instead of a single homogeneous layer. The practice not only allows the use of local aggregates that might not be suitable for conventional pavement, but also provides opportunities for incorporating recycled materials and higher levels of supplemental cementitious materials (SCMs) to produce an economical and sustainable pavement. The practice can also produce durable pavements through the optimization of top lift mixture design with desirable surface characteristics including improved skid resistance and reduced noise. While 2LCP could become a viable and competitive alternative to conventional single-lift paving, challenges of 2LCP are to have the proper paving equipment and pavement construction management, the right mixture proportions to ensure the use of local materials in the bottom lift to result in an economical placement and to ensure a high quality top lift. Through information collected from an extensive literature review, surveys, interviews and a recently hosted 2LCP workshop, a summary of benefits of 2LCP from sustainability and cost effectiveness perspectives was provided. Four 2LCP projects recently constructed in the U.S. were summarized as case studies. This paper also discusses additional requirements in materials, equipment and construction, project scheduling and jobsite management, which will be beneficial in the implementation of 2LCP construction.

Keywords: *Two-Lift concrete, recycled concrete aggregate, pavements*

1. INTRODUCTION

Two-lift concrete paving (2LCP) involves placing two (different) layers of concrete (fresh-on-fresh or wet-on-wet) rather than the traditional method of using a single, homogeneous layer of concrete that is commonly used in the U.S. In a typical 2LCP section shown in Figure 1, the bottom layer is thick and typically consists of lower quality concrete mixtures or aggregate, in many cases recycled aggregate or local aggregates that are not applicable for use in surface courses. The top layer is thin and consists of high-quality concrete and aggregate, often imported, that provides better durability, reduced noise, and improved skid resistance. The two major benefits from2LCP are: (1) permits more economical concrete to be used for the bottom layer through allowing significant amounts of local materials, including aggregates that are considered not appropriate for surface courses, such as recycled aggregates (recycled concrete aggregate (RCA) and reclaimed asphalt pavement (RAP)) and carbonate (soft) coarse and fine aggregates, together with using lower cement contents and higher amounts of supplementary cementitious materials (SCMs), and (2) more efficient and economical use of specialized mixtures to produce desirable surface characteristics for top layers with superior durability, reduced noise and improved skid resistance.

2. NOMENCLATURE

- Concrete
- Two-Lift
- Recycled Concrete Aggregate

The construction sector has grown at a moderate rate in recent years, owing to rising population in emerging countries, as well as increased residential development and the need for infrastructure improvements in developed countries. The long-term outlook for the global construction sector is positive. According to Eurostat, the construction sector is predicted to grow faster than the global gross domestic product (GDP) over the next decade. Pavement Quality Concrete is a high-quality concrete layer applied over a rigid pavement or cement concrete road (PQC). PQC is a type of Plain Cement Concrete (PCC) that must be hard and robust enough to transmit vehicle weight evenly to the bottom layers without distortion. PQC stands for "extremely low workable concrete."

Recycling construction concrete wastes into aggregates in fresh concrete mixes is a recent trend for limiting environmental pollution by reducing the requirement for natural materials and minimizing concrete waste. The feasibility of using demolished concrete as coarse aggregates has been studied in

a number of studies. Given the creation of large quantities of building waste and the significant changes in the imposed environmental standards, the reuse of building waste is attracting increasing interest around the world. Each year, the globe utilizes between ten and eleven billion tonnes of natural aggregate. Many concrete structures are demolished each year for a variety of causes, resulting in millions of tonnes of demolished garbage. According to recent reports, the annual amount of destructed concrete in Europe and the United States is roughly 50 and 60 million tonnes, respectively.

RIGID PAVEMENT:

- Rigid pavements are those which possess noteworthy flexural rigidity.
- It possesses flexural strength
- Load transfer is by the way of slab action and it distributes the wheel load to a wider area below.
- Flexural stresses will be developed due to wheel load temperature changes.
- Tensile stresses will be developed due to bending action of the slab under the wheel load.
- It does not deform to the shape of lower layer, but it bridges the minor variations of the lower layer.

Rigid pavement consists of the following components:

i. Cement Concrete slab
ii. Base course
iii. Soil sub grade

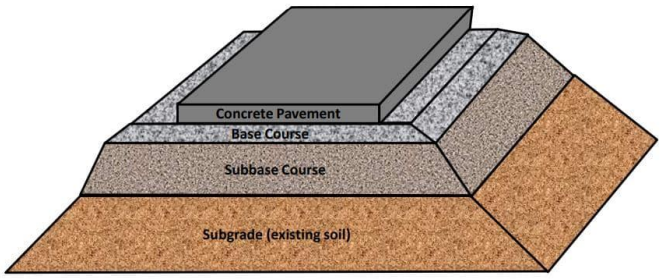

Figure 1: Cross-section of Rigid Pavement

3. LITERATURE REVIEW

a) Gupta & RK (2018):

To economize the resources from the earth such as river sand, stone, soil, etc. and energy to protect the environment from various pollutants, C & D waste management requires to be focused upon. C & D waste has potential use after processing and the application such waste is typical in industrialized countries but in India so far, no systematized effort has been made but some NGOs and Private companies have taken the initiative to reduce,reuse and recycle the C & D waste.

b) Raj & Choudhary (2021):

Demolition waste is waste debris from destruction of a construction. Construction industry in India generates about 10-12 million Tons of waste annually. While Retrievable items like bricks, wood, metal, titles are recycled in India, Concrete and masonry waste (>50% of total waste) are not recycled. A defined manual is not available with regulatory authorities for effective management of Construction and Demolition (C & D) waste.

c) Surya T. Swarna, Kamal Hossain, Muppireddy A. Reddy & Braj B. Pandey

TLCP (Two-lift concrete pavement) perform well by laying a thick lean concrete layer and a thin pavement quality concrete layer because as there is an increase in a lean concrete layer thickness of TLCPs, there is a decrease in stresses in the lean concrete layer.

- The load associated stresses and curling stress were found to be significantly lower in TLCP compared to conventional concrete pavements. Predominantly, the TLCP perform better than unbonded pavements, especially at high-temperature gradients.

- It is also noticed that, if the thickness of the PQC layer is higher than that of LC layer in two-lift concrete pavements, then the stresses inducing at the interface are significantly higher due to a non-linear temperature gradient.

- Although the labour expenses and machinery cost are higher for TLCP, the material cost is less as it has thick LC and thin PQC layers. So, the total construction cost for TLCP is lesser than conventional concrete pavements.

d) Alexander S. Brand, Armen N. Amirkhanian, and Jeffery R. Roesler (2021):

Five concrete mixtures were designed with a combination of the following aggregate sources: virgin coarse and intermediate aggregate, virgin fine aggregate, coarse FRAP, and coarse RCA. Cylinders, flexural beams, single-edge notched beams, and large-scale full-depth and two-lift concrete slabs were all cast from the same concrete mixtures and tested. All laboratory strength results demonstrated that these specific recycled aggregate concrete mixtures had significantly lower strengths and moduli relative to those of virgin aggregate concrete by as much as 60%; these findings suggest that existing

Mechanistic–empirical pavement design methods would predict shorter performance life for the lower flexural strength of the recycled aggregate concrete relative to the virgin aggregate concrete.

4. FLEXURAL TEST PERFORMED ON TWO-LIFT BEAMS

Beam Type	Load (N/mm^2)
Pure NCA	4.2
Bottom NCA – Top RCA	4.16
Bottom NCA – Top RCA	4.22
Bottom NCA – Top RCA	4.32

5. CONCLUSION

Since sustainability is becoming increasingly important in concrete paving, two-lift concrete paving (2LCP) is becoming an effective tool to address environment challenges. 2LCP opens up opportunities not only to use local and/or recycled materials that in the past have not been suitable for concrete pavements, but also to incorporate surface techniques to address the noise and safety challenges and public demands. While 2LCP does result in increased construction costs associated with additional equipment, labor and scheduling effort, reported savings from the use of lower-quality, less expensive concrete and aggregate in the bottom lift could be sufficient to offset the additional costs. Case studies of recently constructed projects showed that 2LCP projects can be a viable alternative from both sustainability and economics. An extensive summary based on recent experiences in Europe and the U.S. provides specific guidelines and recommendations that could be helpful in the implementation of 2LCP construction. Although 2LCP is becoming a technical feasible technique, successful implementation of the technique will require more demonstration projects to promote the practice and to eliminate difficulties and challenges for 2LCP implementation. Laboratory and field studies to determine optimum time lag between the two lifts under different conditions, minimum bond strength, and CoTE on debonding issues and/or thermal deformation are also needed. Other applications such as RCC in the bottom lift and/or pervious concrete in the top lift can also be studied to explore additional environmental and economic benefits of 2LCP.

REFERENCES

[1] Gupta & RK,2018, “The Impact of C & D Waste on Indian Environment: A Critical Review”.

[2] Raj & Choudhary, “CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT LEGISLATION AND FRAMEWORK IN INDIA - A MINI REVIEW WITH BEST PRACTICES IN C & D WASTE MANAGEMENT”.

[3] Surya T. Swarna, Kamal Hossain, Muppireddy A. Reddy & Braj B. Pandey, “A mechanistic and economic analysis of two-lift concrete pavements”, Road Materials and Pavement Design.

[4] Alexander S. Brand, Armen N. Amirkhanian, and Jeffery R. Roesler,2020,” Flexural Capacity of Full-Depth and Two-Lift Concrete Slabs with Recycled Aggregates”.