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Review Paper on Stress Analysis of Pavement Quality Concrete Made using Recycled Concrete Aggregate

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Abstract - *There is a Basic shortage of normal aggregates and hence the use of demolished building material as Recycled coarse aggregate (RCA) is on demand. Using the demolished building material as recycled coarse aggregate helps in saving normal aggregates, reduces the load on landfills, decreases energy consumption and can provide cost savings. RCA comprises of crushed, graded inorganic pieces processed from the materials that has been used in the construction and demolition debris. This aggregate contains impurities like crushed clay bricks, crushed ceramic material and gypsum. In this paper, stress analysis using different softwares is being reviewed to understand the possibility of its effectiveness. Different softwares like Ansys, Kenpave, are helpful in analysis of both stress and deflection values with high accuracy.*

Key Words: Recycled coarse aggregate (RCA), Rigid pavement, Compressive strength, Flexural strength, ANSYS, KENPAVE.

1. INTRODUCTION

Concrete is the most commonly utilized man-made material on earth. It is an important construction material used extensively in buildings, bridges, roads and dams. It uses range from structural applications to paviors, kerbs, pipes and drains. Its strength, flexibility and economy have it the most significant material for construction purposes. Concrete is a composite material, consisting mainly of Portland cement, water and aggregate (gravel, sand or rock). When these materials are mixed together, they form a workable paste which then gradually hardens over time. Due to the increase in demand of its use, it has resulted in exhaustion of natural aggregates. It is required to adopt new methods and materials for concrete mixes.

Due to the depletion of the natural aggregates, it has led to explore and use recycled coarse aggregates. Recycling is defined as the action or process of converting waste into reusable material. Construction and demolished waste (C&D) is generated during the construction, renovation, and demolition of building or structures. These wastes include materials such as concrete, bricks, wood, and lumber, roofing, drywall, landscape and other wastes.

Accordingly, in the present study an effort was made to replace natural coarse aggregates with recycled concrete aggregates in different proportions and study their influence. Stress analysis is one of the important parameters to look upon. There are different software in which rigid pavement slabs can be designed. Recycled coarse Aggregates shows less strength than virgin aggregates. So a proper study on designing slabs to minimize and know the location of critical stress and deflection is necessary to carry out to avoid the failure of the pavements. Few software are ANSYS, KENSLAB AASTHOware etc. few stresses caused are temperature stress, warping stress, stress due to friction, joint stress etc.

1.1 Rigid Pavements

Rigid pavements are those which contain sufficient beam strength to be able to bridge over the localized sub grade and areas of inadequate support. Load is transmitted through beam action slab in rigid pavements. Rigid pavements reduce stress concentration and distribute the reduced stresses uniformly to the area under the slab.

- Deflection is very small hence named as rigid pavement
- The high flexural strength is predominant and the subgrade strength does not have

much importance as in case of flexible pavement
- Continuous slab can be provided without joints.
- No phenomena of grain to grain load transfer exists
- Life span is more compared to flexible pavement
- Low repairing cost but completion cost is high.

1.2 Recycled coarse aggregates

Recycled aggregates are those aggregates obtained from the demolition wastes. demolished waste (C&D) is generated during the construction, renovation, and demolition of building or structures. These wastes include materials such as concrete, bricks, wood, and lumber, roofing, drywall, landscape and other wastes. Due to the increase in demand of construction activities past few decades led to the exhaustion of natural aggregates. Therefore, the scope for recycled aggregates has increased and new construction methods have been implemented.

1.2.1 Advantages of Recycled aggregates

•Save landfill space
•Conserve natural resources by reducing the need for gravel mining water, coal, oil and gas
•When used as the base material for roadways, reduces pollution from waste transport to landfills and dumps
•Create employment opportunities, cost effective
•Drags down material and waste transport expenses
•Recycling one ton of cement could save 1,360 gallons water, 900 kg of CO2

1.2.2 Disadvantages of Recycled aggregates

•Downgrading of quality of concrete
•Increase in water absorption capacity ranging from 3% to 9%
•Decrease in compressive strength of concrete (10-30%)
•Reduces workability of concrete
•Lack of specifications and guidelines
•Less durability of RAC, however few papers have shown an improvement in the durability by mixing it with special materials like fly ash.

2. LITERATURE REVIEW

Rishikesh A. Khope and Milind V. Mohod This paper deals with the use of recycled aggregates for rigid pavements replacing natural aggregates. The performance of rigid pavements depends on the stresses and deflections imposed by repeated traffic loadings and hence there is a need to analyze pavement for wheel load stresses. Finite element method (FEM) is the most popular mechanistic tool available for analysis. Analysis of concrete pavements by using ANSYS software has been used for this work. In this study, the use of recycled aggregate in the rigid pavement construction is discussed. The tests were carried out for various types of mixes and the results shown are 1) mix (70%NCA+30%RCA) showed the maximum strength and maximum stresses for the different load, thickness and K value out of the five mixes. 2) This study confirms that the use of ANSYS software has a great potential as a powerful tool for a modeling of rigid pavement.

Mohd. Imran Khan. Mohd. Abdul Qadeer, A. B. Harwalkar In this paper, the study of the effect of temperature variation on concrete pavement using ANSYS software was presented. Analysis for temperature stresses has been done using both linear and non-linear temperature gradients between top and bottom of pavement slab. The results obtained using the linear temperature gradient has shown reasonable agreement with the results obtained from the three other mechanistic models: given by software KENSLABS, ILLI-SLAB and JSLAB. From this paper, it was found out that 1) Non-linear temperature distribution caused higher tensile stresses than the linear distribution of temperature. The difference in tensile stresses resulting from the two distributions was 18.95 – 23.65%. 2) The finite-element model is a powerful tool for analyzing stress and strain development in plain-jointed concrete pavements. 3) The variation of length of slab does not influence the curling stresses distribution in both the case of positive and negative temperature gradient. But curling stresses increases with increasedslab thickness

Prof. Baswa Kumar Biradar In this paper, grade of the concrete used is M30. The rigid pavement analysis has been carried out in FEM based KENPAVE software. Variation of middle, edge and corner stress is found for the different slab thickness. For the analysis a single axle with single wheel and dual wheel are considered. From the paper it was found that 1) The rigid pavement slab is analyzed on the KENPAVE slab by inputting the experimental values

obtained. Analysis was made for two different load classes. 2) The wheel load stresses are decreasing with increase in slab thickness. 3) For all cases of loading, maximum stress occurs at corner region than edge and center regions.

NAVEEN B C I In this paper, replacement of natural aggregates by recycled aggregates up to certain limits has shown a very good compressive strength and concrete properties and the obtained results are carried to the KENPAVE software and an analysis is done on the concrete pavements. The KENPAVE software can analyze linear, non-linear and viscoelastic material properties for each layer. KENPAVE software can perform damage analysis and can handle up to 19 layers either bounded or unbounded. From the paper, a rigid pavement was modeled on KENPAVE using the characteristics value obtained from experimental results. This was analyzed for different load groups, thermal loads and load combinations. With respect to poison's ratio a slight change in stress was observed for a given load group. The corner stress was found to increase with the thickness of the slab. The variation of temperature stress was found to be less for different poison's ratio. It was found that the temperature stress takes an optimum value with variation in thickness.

Now a days three dimensional analysis considered as a powerful tool which captures the pavement response. ANSYS software was discovered to study the effect vehicle load response on pavement. ANSYS is a finite element method based on software. Deformation of stresses-strain analysis state can be done by using both linear and non-linear material properties between upper and lower of pavement structures. The program also includes harmonic excitations, pulse loadings, ramp loadings, and multiple step loadings. The effort made in this research is to develop a three-dimensional finite element program for the analysis of general pavement problems. The geometry and material properties of road pavement are important to evaluate pavement layer conditions. The characteristics of the road pavement under vehicular load are obtained through numerical simulation, when vehicles pass through the pavement under axial load with different layers. This method can be considered as one of the methods to calculate the wheel load response of road pavement.

M. Waseem Mirza, Imran Hafeez, Mumtaz A. Kamal KENLAYER Software as Mechanistic-Empirical (ME), Road Note 31 and AASHTO Design Guide as empirical methodology were used for comparison. The work presented is limited to three layer pavement structure. Comparison was carried for pavement materials treated as linearly elastic and also as non-linear stress dependent. In addition, method presented by AASHTO for effective Resilient Modulus of subgrade was verified by using the damage contributed by individual seasons. The study revealed that the predicted overall structural capacity for the two empirical methodologies i.e. Road Note 31 and AASHTO 1993 are very close, however, significant differences were observed in comparison to ME approach. Relatively higher differences were observed for the two methodologies (AASHTO versus KENLAYER) at the extreme values of material properties and traffic levels utilized in the matrix. For the case of linear analysis, relatively large difference between fatigue life and AASHTO approach was observed compared to performance life based on rutting criteria. For non-linear analysis difference with rutting model was larger compared to fatigue. Finally, use of seasons compared to effective modulus as proposed by AASHTO resulted in differences that are less significant.

H.H. Al- Ghafri , and M. A. Javid Country's economic, social and cultural development is mainly dependent on performance of its highway structure. The rigid pavement exposed to many distresses during its service life resulted due to variation of traffic loading, material properties and climatic conditions. The main objective of this project is to make comparison between manual and computer design for rigid pavement structure under different loading, material properties and temperature regimes. For manual design and computer design, "Westergaard Method" and "KENPAVE software" were used respectively. The stress analysis results revealed that edge stresses are higher as compared with interior and corner location, and stresses estimated at all locations with Westergaard method are significantly lower than stresses estimated with KENPAVE software. Results of sensitivity analysis showed that change in pavement thickness, material properties and wheel load has significant impact on developed stresses at different slab locations.

CONCLUSION

After reviewing the papers, various conclusions can be made:

•Mix (70%NCA+30%RCA) showed the maximum strength and maximum stresses for the different load, thickness and K value out of the five mixes.

•The study confirms that the FEM has a great potential as a powerful tool for a modelling of rigid pavement.

•Non-linear temperature distribution caused higher tensile stresses than the linear distribution of temperature. The difference in tensile stresses resulting from the two distributions was 18.95 – 23.65%

•The variation of length of slab does not influence the curling stresses distribution in both the case of positive and negative temperature gradient.

•The wheel load stresses are decreasing with increase in slab thickness.

• The variation of temperature stress was found to be less for different poison's ratio. The temperature stress takes an optimum value with variation in thickness.

• For all cases of loading, maximum stress occurs at corner region than edge and center regions.

•The stress analysis results revealed that edge stresses are higher as compared with interior and corner location, and stresses estimated at all locations with Westergaard method are significantly lower than stresses estimated with KENPAVE software.

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