OPERATION OF ROLLER COMPACTED CONCRETE IN PAVEMENTS

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Abstract— Roller Compacted Concrete (RCC) pavements are a hybrid approach by blending the conventional concrete and asphalt pavements. RCC uses asphalt machinery to achieve strength and performance as `that of conventional concrete. RCC is a no-slump non-reinforced concrete, whose pavements are strengthened by placement using high density paver machinery and compaction using vibratory rollers. RCC has been a trend in the recent era in view of its cost-effectiveness, quicker construction and durable performance. The objective of RCC is constructability with minimum compaction effort, achieving mechanical strengths, maintaining durability with low permeability and substantial savings in construction cost. This paper highlights the methodology and construction of RCC pavements, outlining its advantages and disadvantages

Index Terms— Roller Compacted Concrete (RCC), Pavement, Soil compaction approach, Concrete consistency approach

I. INTRODUCTION

The name Roller Compacted concrete was coined due to compaction by the vibratory drum and rollers. RCC is stiffer no-slump concrete which can be interpreted as stiff concrete with slump less than 6mm. The paving of RCC is done by asphalt equipment and material selection by conventional method. RCC is made with the same mixture constituents as that of nominal concrete having more volume of fine aggregates. Compact packing and consolidation are possible with the larger fine aggregate percentage. Different sized aggregates are blended to minimize voids, provide better interlocking between each other and acquire better strength. So, RCC is a cement aggregate mixture with proper compaction by rollers. RCC is different from conventional concrete pavements in terms of its mix proportions, workability, paving equipment and process, compaction and finishing. RCC is free from any sort of reinforcements, dowels and forms. RCC pavements are profitable, swiftly constructed ones with improved strength and performance by virtue of its compactability. The factors governing RCC are its reduced cementitious content, larger equipment for construction and economical design. RCC is maintained as a stiffer concrete to support the vibratory roller's weight, proportioned mix to use the cement paste as a coat over aggregates, compacted pavement to increase the pavement's density enabling it to be load bearing. The texture of RCC pavements can be smoothened with diamond grinding, though it is basically open textured like asphalt and surfaced as dense like conventional due to usage of smaller aggregates.

II. MATERIALS USED IN RCC

A. Cementitious Materials:

Cement and pozzolans forms the cementitious content in RCC. Any basic type of cement such as Ordinary Portland Cement, complying with the standard requirements may be considered as key ingredient in the cementitious content of RCC. However, the content of the cement used depends upon the mix proportioning, end usage and project requirements. Pozzolans serve the purpose of filler and establish sufficient compaction.

B. Aggregates

85% of the volume of RCC mix is occupied by

aggregates, which influences its workability, strength, durability and life time performance. Larger amount of fine aggregates passing 75µ sieve is proportioned properly and blended with coarse aggregate. Well graded aggregates are combined for proper gradation.

C. Water

Hydrated cement pasted is formed when cementitious materials are mixed with water. Natural water such as ground water, river water and potable drinking water are good enough to be used in the production of RCC.

D. Chemical Admixtures

Admixtures modify the fresh as well as hardened properties of RCC mix. The selection of type and quantity of admixtures is dependent on the properties, quantities of RCC constituents (cementitious, aggregates, water) and the desired properties of RCC mixture.

III. METHODOLOGY OF RCC

RCC pavements have been designed by combining certain characteristics of conventional concrete and asphalt pavements. Asphalt pavement contributes in terms of gradation of aggregate, placing and compacting while conventional concrete pavement contributes by having the same materials and curing requirements. Densely graded aggregates, proper mix proportioning, well compacted RCC pavements attain the strengths as that of conventional concrete with low permeability.

IV. METHODS OF MIX PROPORTIONING

The mix proportioning techniques can be categorized into two major approaches as follows:

1. Soil Compaction Approach
2. Concrete Consistency Approach

A. Soil Compaction Approach

The most widely used method in RCC pavement mix proportioning is the Soils approach. The relationship between maximum dry density with optimum moisture content (OMC) helps in determining the water requirement of RCC mixture.

Steps involved in Soil compaction approach are as follows:

- Well-graded aggregates are to be chosen such that maximum density grading is reached
- Depending on the requirements of projects, available materials and economic considerations, the cementitious content is selected
- With dry density on Y-axis and moisture content on x-axis, a graph is plotted to find out OMC and maximum dry density.
- Using vibratory methods, specimens are casted and tested for compressive strength. A curve is outlined between cementitious content and compressive strength. Based on the target strength requirement, cementitious content will be finalized.
- After finalizing the OMC and cementitious content values, the mix proportions are calculated.

B. Concrete Consistency Approach

The concrete approach is commonly used in the mix proportioning of RCC hydraulic structures.

- The gradation of aggregates is developed and Cement-mortar ratio is selected.
- Based on the desired mean target strength of RCC mix, the quantities cement, water and admixtures are worked out.
- The aggregate fraction is determined to maintain required workability using Vebe consistometer.
- To implement the devised permeability, the quantities of the parameters are adjusted.

V. CONSTRUCTION OF RCC PAVEMENTS

A. Batching and mixing:

Batch type mixers as well as continuous mixers are used in mixing RCC. Dispersion of materials uniformly should be guaranteed in every mix.

B. Preparation of Subgrade, Subbase and Base course:

The subgrade should be uniformly compacted ensuring minimum 95% of maximum dry density. In RCC pavements, the subgrade, subbase and base course should be supportive and stiff, at the same time allowing RCC pavement compaction.

C. Transportation:

The workability of RCC decreases with time and hence, the transportation time to placement should be maintained not more than 15 minutes from time of mixing.

D. Placement:

Uniformity of surface and requirement of lift thickness should be complied while placing RCC. Minimum of 80% wet density referred should be maintained in the entire width of paving before rolling start. The capacity of RCC paver should have a minimal of 1.5times the production capacity of nominal mixer.

E. Compaction:

This is the most important stage of RCC pavement construction. Sufficient compaction regulates the strength, permeability and density of RCC pavement.

F. Joint construction:

Joints are the depleted areas of strength and permeability in the RCC construction. Hence, care is to be taken for compacting and placing a layer and also in improving bond between layers.

G. Curing:

This aids the pavement to acquire desired strength and maintaining durability of RCC

VI. ADVANTAGES OF RCC

- Swift construction
- Cost-effective
- Resistance to chemical invasion and exceptional durability as a result of low permeability.
- Supports bulky and repeated loads without causing failure
- Sustain impact loads
- Reduced shrinkage and cracking owing to low cementitious content
- High Freezing and thawing resistance

VII. DISADVANTAGES OF RCC

- RCC pavement need to be finished by grinding for smoothness
- Care is to be taken to minimize evaporation losses
- High amount of admixture dosage is essential
- The mixing capacity of a RCC mix is less than conventional concrete
- It is more difficult to compact the edges of the pavement

VIII. RECENT ADVANCES IN RCC

A. MIX DESIGN

Cement, water and aggregates formed the primary constituents of RCC just as in conventional concrete. Basically, RCC was formulated with larger fraction of fine aggregate and less coarse aggregate compared to conventional concrete. Alterations in mix constituents have become essential for the reason that RCC is to be transported to lengthy distances and compact surfaces are to be provided. Evaporation of water content is quite possible in dry climates and so demands lesser transportation time. The incorporation of admixtures in RCC resolves these concerns.

B. PERFORMANCE

The layer thickness of RCC can be reduced by incorporating fibers in it. These fibers aid as crack arrestors, improves the flexural strength of the pavement, minimizes permeability of the surface and contribute to toughness and durability of the surface

C. SURFACE FINISH

RCC is paved by asphalt equipment and is finished with heavy rollers leading to similar surface as that of asphalt but with different colour. Diamond grinding technique is implemented in RCC pavements to enhance smoothness and develop anti-skid texture.

IX. CONCLUSIONS

Roller Compacted Concrete is the leading preference of pavements and is the rapid mode of construction. The mix constitutes of RCC are same as that of conventional concrete with varying proportions to main RCC as a dry mix. RCC has major benefits of higher mechanical strengths, long-standing performance and minimum maintenance. RCC can be treated as an economical substitute of conventional concrete due to its impressive savings in construction.

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