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A Review on No-Fines Concrete Application to Pavements

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Abstract:- **No-Fines Concrete is a concrete made by excluding fine material that is sand or Fine aggregate. The major benefit of using no fines concrete as a pavement is to manage storm water generally in urban areas. No-Fines Concrete is a complex material obtained by mixing Coarse aggregate, cement, water and some admixtures in proper proportions. No-Fines Concrete can be used as hard shoulder material for pavements, also for slope stability etc. As No-Fines concrete has high drainage properties it can be used as a Sub-Base material and Base-Course Materials for Flexible pavements as well as rigid pavements. In this paper, a review is done to study various mechanical properties such as Compressive strength, Flexural strength, permeability density etc. of No-Fines concrete. In addition, No-Fines Concrete gives high thermal insulating properties and helps in improving skid resistance due to rough texture at top. Hence, the paper review's about application of No-Fines concrete as rigid pavement by making it cost effective and by eliminating fine material.**

Keywords:- *NFC (No-Fines Concrete), Steel Slag No-Fines Concrete (SSNFC), Sustainable Development, Mechanical Properties (Compressive Strength, Tensile Strength, Permeability etc.)*

I. INTRODUCTION

No-Fines Concrete is a synthesized material comprising of aggregate (size >4.75mm), Cement and water. NFC is not exactly the equivalent as conventional concrete but it contains no fines. The total mixture is strengthened together by a cement bond and water. Compared with common concrete, NFC has a reduced compressive strength, surpassing permeability and low specific weight about 70% of conventional concrete. No-fines concrete has exceedingly porous mass with vast air spaces [1]. Not at all like traditional surface, which has a void proportion somewhere in the range of 3 to 5%, No-Fines Concrete have voids ranging from 15% to 40% relying upon its appliance. The higher porosity in NFC results in reduced compressive strength as well as reduced flexural strength. Requirement of Concrete for pavement appliances must have compressive strength in between 20 MPa to 25 MPa [2]. While compressive strength of NFC ranges from 5 MPa to 15MPa depending upon mix [3]. Durability of NFC must be considered for long-term performance. Compared with ordinary concrete, NFC has a lower compressive quality, higher porousness, and a lower unit weight, roughly 70% of traditional concrete. No-fines concrete has highly permeable mass with large air spaces. It is a mixture of coarse aggregate particles each surrounded by a coating of cement paste, approximately about 1.25 mm thick. As the aggregates to be used is almost -single sized which results in formation of enough voids and thus preserve its most important properties of light weight and eliminating rise of dampness [4]. NFC can be used in foundation as well as in floors in place of lime concrete where elimination of rise of salt and moisture is desirable. The thermal conductivity of a pavement made of NFC and a pavement of the conventional concrete same thickness is about the same. It can be used as damp proof course for brunt brick walls sub structure [5].

➢ *Advantages of NFC*

- Reduction in sound produced by vehicles on rigid pavements
- Improved skid resistance
- Reduce storm water runoff
- Ground water recharge

II. LITERATURE REVIEW

Harber et al. [1] studied the non-pavement applications of NFC are in buildings, tennis courts, drains and drain tiles, while pavement applications are for low volume road surfacing, parking lots and pavement edge drains. Failure occurrence of raveling is after 10 years of construction and excessive uplift pore pressure can be reduced by using NFC as pavement (rigid pavement), also it can be used as storm water management system. Cost saving was obtained when compared with conventional concrete. As per Southern California Mixed Concrete Association NFC pavement has life of 20-40 yrs. NFC are light in color hence reducing ground level ozone.

Lim Emiko et al. [4] used steel fibers to enhance mechanical properties of No-Fines Concrete. Steel fibers helps in reducing surface cracks developed due to heat of hydration in conventional concrete. He concluded that Steel fibers aids in increasing the compressive strength and flexural strength. At max 2%, fibres were used to obtain a composite mix at Aggregate: Cement ratio 4: 1. In addition, when No-Fines Concrete (NFC) was compared with porous asphalt (Open Graded Premix Carpet also known as OGPC) with same porosity and other similar properties, NFC gives higher permeability, high compressive strength, and high flexural strength with reduction in sound.

Rama Mahalingam et al. [6] worked on various mixes to study mechanical properties of NFC and had obtained that 4:1 (Aggregate: Cement) ratio gives maximum compressive strength of 16 MPa and further as the ratio increases the strength decreases. Increased porosity leads to increase in permeability and decrease in compressive strength. In addition, pervious concrete can be used as sustainable choice in various storm water management applications.

Mulligan et al. [7] studied on existing pervious pavements with respect to their thickness depending upon loadings etc. and concluded that vehicles with ESWL (Equivalent Single Wheel Load) ranging between 1.5-3 Tones (approximately 580 vehicles/day) can be withstand by NFC mix (4:1 Aggregate: Cement) . More deterioration takes place at entrance and exit points when used in parking lots. For heavy load vehicles Asphalt overlays should be done.

D P Maynard et al.[8]A fine No-Fines Road was made in England in 1970 by senior engineer Concrete Association of Great Britain of approx. 183 meter length and 50 mm thick. Main purpose of this road was to improve drainage properties. As during winter, the roads get covered with snow and NFC helps in draining water from the surface. No-Fines Concrete also reduces vehicle skidding which happens due to wet top road surface due to frost.

Ghafoori et al. [9] concluded that NFC could be used as pavement edge drains as it has approximately 35% to 40% of voids, which helps in flowing of water and reduces cutting of edges of road shoulders.NFC can be used as an base course material (main function is to prevent capillarity action). Ghafoori et al also concluded that there is no enhancement in mechanical properties by changing different curing methods. He obtained an In-direct tensile strength of NFC ranging between 1.22 MPa to 2.83 MPa. Also, as the aggregate cement ratio decreases indirect tensile strength increases. In addition, lower aggregate cement ratio gives enhancement in increased mechanical properties.

Joung et al. [10] used silica fume, High range water reducing admixture (HRWR) and fly ash to increase compressive strength of NFC and following results were obtained :-

Type of Mix	**28 day Comp. Strength (N/mm2)**	**Cement: Coarse Aggregate ratio**	**% of admixtures**
Controlled Mix	9.5	1:6	-
High Cement Mix	16.2	1:3	-
Silica Fume + Cement	6	1:3.5	5% of Cement Volume
Silica Fume+HRWR+ Cement	8	1:3.5	Silica-5% of Cement HRWR- 27% of water
Fly-Ash + Cement	16.25	1:4.3	25% of Cement volume

Table 1

Muttar et al. [11] used polypropylene fiber to study compressive strength, tensile strength and density of NFC and obtained that for ratio of 3:1 Aggregate: Cement and at water cement ratio 0.31 gives density, cube compressive strength and tensile strength up to 2025 kg/m3, 17 MPa, 3.1 MPa respectively. While adding polypropylene fiber up to 0.9% gives density, cube compressive strength and tensile strength up to 2030 kg/m3, 20.5 MPa, 3.82 MPa respectively.

N.F.Ariffin et al. [12] used Re-Dispersible Polymer Powder (RDP) to produce high performance No-Fines Concrete. Re-Dispersible Polymer powder majorly helps in reducing setting time and helps in increasing on mechanical properties. NFC mixture with powder polymer gives an increased compressive strength up to 17 MPa. In addition, they used Polymer Latex (a type of liquid polymer mixed with water in different proportions maximum up to 5%) and obtained lower compressive strength up to 13 MPa. There was no effect on permeability by use of polymers. In addition, there was no change in percentage of Air-Voids.

Sriravindrarajah et al. [13] proposed to use Recycled Concrete Aggregate (RCA) to prepare No-Fines mix. Recycled Concrete Aggregate (RCA) was obtained by crushing concrete blocks, waste concrete in crushers and screened on mechanical vibrating screens to get required size aggregates. Sriravindrarajah et al. concluded that Recycled Concrete Aggregates (RCA) gives maximum compressive strength of 12 MPa at 4:1 Aggregate: Cement ratio. He also concluded that as porosity increases compressive strength decreases. In addition, the major drawback of using Recycled Concrete aggregates (RCA) is that it has low impact value and higher abrasion value. Hence recycled aggregates shows lower mechanical properties compared to conventional aggregates.

P.J.Ramadhansyah et al. [14] studied on SEM (Secondary Cementitious Materials) that to be used to reduce cement content. He studied on material named Nano-silica. Nano-Silica is obtained by grinding rice husk at controlled temperature in a close furnace. Nano-Silica is a type of Ash that acts as a binding material parallel to cement. He studied on various proportions of Nano-Silica in parallel with cement content at different aggregate is to cement ratios at different water contents. He concluded that Nano-silica could be used as Secondary Cementations Material (SEM) and can be mixed with cement to improve strength. At most 8% to 10% of Nano-Silica can be used in combination with cement. Best suitable Aggregate is to cement ratio was 4:1 with w\c ratio ranging between 0.35 - 0.4.

Guo Peng et al. [15] used steel slag to produce NFC and concluded that compressive strength obtained was up to 20 MPa while flexural Strength obtained 3.5-5 MPa. Steel slag is a kind of industrial waste, making full use of which can recycling the resources and reducing environmental pollution. After adding steel slag to concrete, according to the report, different water-cement ratio, ratio of aggregate to cement and Shape and bulkiness of aggregate influences on strength and water permeability of No-Fines Concrete, a certain kind of SSNFC (Steel slag No-Fines Concrete) is produced, whose void ratio about 15% to 20%, permeability about 10mm/s, flexural strength up to 4.0 MPa. Hence conclusion was that, SSNFC (Steel slag No-Fines Concrete) is a modern material which can enhance the service performance of low-volume road.

Tennis et al. [16] used recycled concrete aggregate to produce No-Fines Concrete with natural aggregate. He studied on various mixes by using both the aggregates. His focus was on mechanical properties of NFC and he concluded that as the percentage of recycled aggregate increases simultaneously there is decrease in compressive strength and flexural strength. At max 35% of recycled concrete aggregate can be used in combination with natural aggregate at ratio 4.06:1 (Aggregate: Cement) to get compressive strength of 15MPa.

Evangelista et al. [17] had a review on NFC and concluded that NFC can be used in parking lots, walkways, to produce pavement blocks etc. It can be designed to be used as a pavement for Axle load up to 3 tones. While comparing it with conventional concrete compressive strength decreases but permeability increases. In addition, it gives cost savings up to 600 rupees per cum. NFC pavements can help in reducing storm water runoff and can be used for recharging ground water.

Sonebi et al. [18] had an overview on No-Fines Concrete mix design, mechanical properties, durability and applications. He concluded that Aggregate: Cement ratio ranging from 4:1 to 6:1 with an water cement ratio ranging from 0.27 to 0.43 shall be used for obtaining maximum compressive strength. Water reducing admixtures were used for easy handling and placing of these concrete as more water drains off the cement paste. NFC pavement can be, used for parking lots, rigid drainage layers under exterior areas, base course for roads, surface course for parking lots and various areas.

Hesami et al. [19] studied on No-Fines Concrete using rice husk and fibers. Rice husk ash shows amorphous property due to which amorphous silica is produced (85 to 90%). He concluded that 8%-10% of rice husk ash can be replaced by binder and simultaneously by adding fibers there is enhancement in mechanical properties of NFC. The w\c ratio of maximum 0.33 should be used to obtain maximum Compressive strength, Tensile strength and Flexural strength. The permeability obtained ranged between 0.08cm/s to 0.48cm/s and porosity ranging from 8% to 29%. Hence, it is one of the best suitable materials for drainage layer in road sub-bases.

Malhotra et al. [20] studied that the density of NFC using normal aggregates ranges from 1602to 1922 kg/m3. The clinker aggregate was used to produce NFC and obtained a density of 961 kg/m3. NFC is a self-packing product. He additionally proposed that the utilization of mechanical vibrators and vibrating rammers is not suggested for NFC concrete. A light abrasion could be satisfactory and used to guarantee that the solid achieves all segments of the formwork. This isn't an issue with Conventional cement concrete since it is more workable in nature than NFC. The light rodding guarantees that the solid has infiltrated every one of the regions hindered by strengthening steel.

Abadjieva et al. [21] studied that the cube compressive strength of No-Fines Concrete escalates with time similar to conventional concrete. The No-Fines Concrete (NFC) samples trialed have Cement: Aggregate ratio ranging from 1: 6 to 1: 10. The 28 day cube compressive strength acquired by these various mixes ranged between 1.1 MPa and 8.2 MPa respectively, with the Cement: Aggregate ratio of 1: 6 best suitable. He comes to an end that the major reason for decreased compressive strength and decreased mechanical properties was caused by the escalation in void ratio and porosity of the No-Fines Concrete samples. The strength acquired can bear structural load of load bearing walls and similar applications. Ghafoori bring out No-Fines Concrete sample with a cube compressive strength ranged up to 20 MPa when an Cement: Aggregate correlation of 1: 4 used. He also carries out research on the effect of the Cement: Aggregate relationship on the Tensile strength and Flexural strength of No-Fines Concrete (NFC). This review only suggests that cement: Aggregate correlation ranging from 1: 4 to 1: 6 while at max of 1: 10 is suggested. The major conclusion was that the strength decreases with an increase in Cement: Aggregate ratio. He analyzed that the tensile strength and flexural strength of No-Fines Concrete were quite lower than those obtained from conventional concrete.

III. CONCLUSIONS

No-Fines Concrete provides a permeable medium due to which water drains to the underlying soils.NFC is an economical material that can possibly supplant the utilization of traditional pavements in places where substantial movement of heavy load vehicles is restricted for example parking lots, walkways, gardens, residential areas, rural roads etc. More applications may be possible if raveling can be reduced which occurs on top surface of pavement. The strength of No-Fines concrete majorly depends upon shape and size of aggregates. It is been observed that using variable sized coarse aggregate gives more compressive strength than using single sized coarse aggregate. However, the major drawback of using variable sized coarse aggregate results in reduced permeability. As No-Fines Concrete has rough texture, it increases the skid resistant property for the users resulting road user safety. No-Fines Concrete can be used in urban areas as pavements, which are subjected to heavy rainfall. Use of various other materials like steel fibers, Nano-silica, polymers, and recycled concrete aggregates etc. results in enhancement of mechanical properties of No-Fines Concrete. NFC can be used as rural road pavement with a design load of 3 Tones. In addition, No-Fines concrete can be used as a Sub-base material for both rigid pavements as well as flexible pavements. Excluding the permeability characteristics of No-Fines Concrete, Asphalt overlays can also be done.

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