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Research article

PULVERIZED COCONUT FIBRE AS AN ADDICTIVE IN ASPHATIC CONCRETE

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Abstract

This paper investigated the effect of pulverized coconut fibre (PCF) as an additive in asphaltic concrete. Coconut husks were procured from Ile-Ife, Osun- State while aggregates and bitumen were obtained from Hajaig Construction Company Limited, Ado-Ekiti, Ekiti – State. The coconut fibre was shredded mechanically after dehusking. The materials were characterized using normal procedure. Asphaltic concrete samples were prepared with the addition of pulverized coconut fibre (PCF) at 0, 4, 6, 8, 10 and 12 % by weight of total mix. The samples were subjected to Marshall Stability test and the stabilities and flows were determined. The result showed that the stabilities and flows increased as the percentages of PCF content increased. The study concluded that PCF as an additive in asphaltic concrete could improve high road temperature, over loading, rutting and moisture resistance of flexible pavements.

Keywords: Pulverized Coconut Fibre, Asphaltic Concrete, Stability, Flow, Flexible pavement

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Introduction

Coconut fibre is extracted from the outer sheet of a coconut. The common name, scientific name and plant family are coir, cocos nucifeta and arecaceae (palm) respectively. There are two types of coconut fibre, brown fiber extracted from matured coconuts and white coconut extracted from immature coconuts. Brown fibres are thick, strong and have high abrasion resistance. White fibres are smoother and finer, but also weaker. Coconut fibers are commercially available in three forms; namely bristle (long fibres), mattress (relatively short) and decorticated (mixed fiber). These different types of fibres have different uses depending upon requirement. In engineering brown fibers are mostly used [1].

The Coconut Palm (cocos nucifera) though not indigenous to Nigeria grows well in places with a mean annual temperature of 25 °C – 28 °C and an annual rainfall of 200 mm. Great potentials exist for increasing coconut production and productivity in Nigeria [2]. According to the official website of International Year for Natural Fibers 2009, approximately, 500,000 tonnes of coconut fibres are produced annually worldwide. Its total value is estimated at One Hundred Million Dollars. There are many advantages of coconut fibres e.g. they are moth-proof, resistance to fungi and rot, provide excellent insulation against temperature and sound, not easily combustible, flame-retardant, unaffected by moisture and dampness, tough and durable, resilient, springs back to shape even after constant use, totally static free and easy to clean [3]. Coconut fibre has elongation properties that could make it to absorb or withstand stretching energy [3]. [4] reported that coconut fibre retained most of its tensile strength when subjected to alternate wetting and drying, as well as continuous immersion in water, saturated lime and sodium hydro chloride.

A study conducted by [5] showed that the addition of coconut fibre to asphalt mix increased the resilience modulus (Mr) by approximately 14 %. [6]. also reported that the addition of 0.75 % of 5 mm coconut fibres (strands) by weight of the asphaltic increased the value of its marshal stability by between 10-15 %. Asphalt concrete mixture is widely used for paving roads and highway surface because it is easy to construct and repair.

Long-life asphalt pavement is in high demand as part of reducing expenses for public works and maintenance u;osts. Conventional asphalt concrete pavement has several draw backs. It is vulnerable to rutting caused by traffic load and damage caused by petroleum oils [7]. Damage to highways mostly occurs in the top layer, in the binder and erosion layer, rather than the foundation and lower layers. Damage to the binder and erosion layers, generally include, surface cracks, deformations, wheel ruts and potholes [8].

Damage to roads in Nigeria is caused by environmental factors, overloading and construction malpractices. As a tropical country, Nigeria has a problem with increases in the road surface temperature. Therefore a surface layer able to resist temperature changes is required. A possible approach is the use of fibre additives mixed into the asphalt. Fibre- added materials are derived from synthetic or natural fibre [9].

Asphaltic concrete for flexible pavement flow in response to plastic deformation at high temperatures, such deformations accumulate due to repetitive loads thereby leading to early failure of the road pavement structure. The need to address this problem amongst others becomes imperative; hence this study.

Materials and Method

Coconut husks were procured from Ile-Ife, Osun State. The aggregates (coarse and fine) mineral filler and bitumen were obtained from Hajaig Construction company limited, Ado-Ekiti, Ekiti State. The coconut fibre was shredded mechanically after dehusking. Grading specific gravity density, flakiness, aggregate impact and crushing values soundness tests were carried out on the aggregates and the pulverized coconut fibre. While penetration test was carried out on the bitumen. The amount of binder used was the optimum value determined from the mix design [10]. Asphaltic concrete samples were prepared with the addition of pulverized coconut fibre (PFC) at 0, 4, 6, 8, 10 and 12 % by weight of total mix. The samples were subjected to Marshall Stability Test. The stability and flow values were determined.

Results and Discussion

The grading curves (Figure 1) for pulverized sand and quarry dust, pulverized coconut fibre, with uniformity coefficient of 10.71, 13.42 and 14.14 respectively (Table 1), show that the materials are well graded [11]. The aggregates grading curve (Figure 2) falls within the grading envelope of the General Specifications (Roads Bridges)

[12]. This indicates that the aggregate grading is suitable for asphaltic concrete. The specific gravities for 9.5mm, 12.7mm and 19mm crushed stone were 2.72, 2.72 and 2.66 respectively. While those for quarry dust, pulverized coconut fibre (PCF) and bitumen were 2.71, 0.112 and 1.02 respectively. The specific gravity value of 0.112 for PCF showed that it is a light weight material. Bitumen specific gravity of 1.02 classifies it as a 60 – 70 penetration grade bitumen [12]. The density of the mixed aggregate of 2.19g/cm^3 obtained is satisfactory [13].and [14]. The flakiness aggregate impact value (AIV) and aggregate crushing value (ACV) for the mixed aggregate were 29.2, 1.5 and 16.7 % respectively. These values are within the acceptable limits[15]. The fine aggregates angularity values for PCF, quarry dust and river sand were 43.45, 44.52 and 44.19 % respectively. These values fall within fine aggregate angularity criteria [10]. The soundness test values for the quarry dust and PCF were 5.98 and 14.38 % respectively. The lower % for the PCF shows that it would be less susceptible to disintegration under the action of weather than quarry dust [16]. The optimum bitumen content from the mix design was 5% as shown in Figure 3. The Marshall Stability value is generally considered to be a measure of the mixtures strength, while the flow index value represents its resistance to creep or plastic flow [17]. The Marshall Stability Curve (Figure 4) shows that, the stability of the modified asphaltic concrete increased as the percentage of the PCF in the mix, reaching its optimum value at 8 %. The improvement of stability in the asphaltic concrete can be attributed to the binder adhesion development between the bitumen and aggregate particles due to improvement in the rheological properties of the bitumen as a result of the addictive. Increase in cohesion properties of the binder enhances higher fatigue resistance, improved thermal stress cracking, decrease in temperature susceptibility and reduction of rutting [18]. The Marshall flow (Figure 6) of the asphaltic concrete increased steadily as the percentage of PCF increased in the mix; until an optimum point was reached. The improved flow property of the asphaltic concrete therefore is attributed to the tough and resilient nature of the coconut fibre [3]. [19] reported that, coconut fibre has the highest percentage by volume of lignin, which makes the fibre very tough and stiffer when compared to other natural fibres. He attributed this to the fact that the lignin helps provide the plant tissue and individual cells with compressive strength and also stiffens the cell wall of the fibre where it protects the carbohydrate from chemical and physical change.

Conclusion

The use of pulverized coconut fibre as an additive in asphaltic concrete was investigated. The additive manifested synergistic effects with the main bitumen binder, leading to improved properties of the asphaltic concrete produced. Consequently, with higher Marshall Stability and flow values, the modified asphaltic concrete could have higher road temperature, overloading, rutting and moisture resistance.

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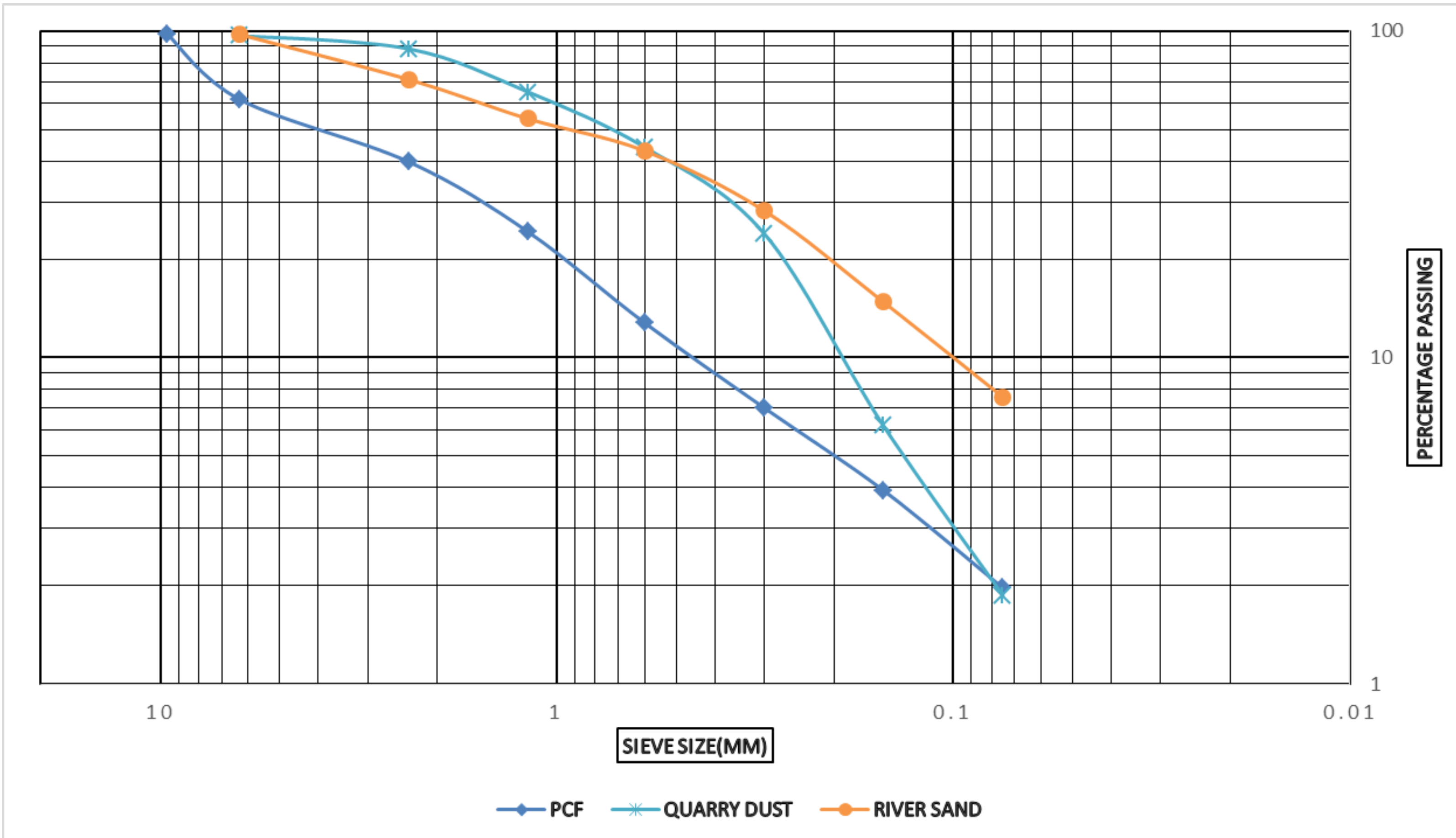

Figure 1: Grain size distribution curve for fine aggregates material and PCF

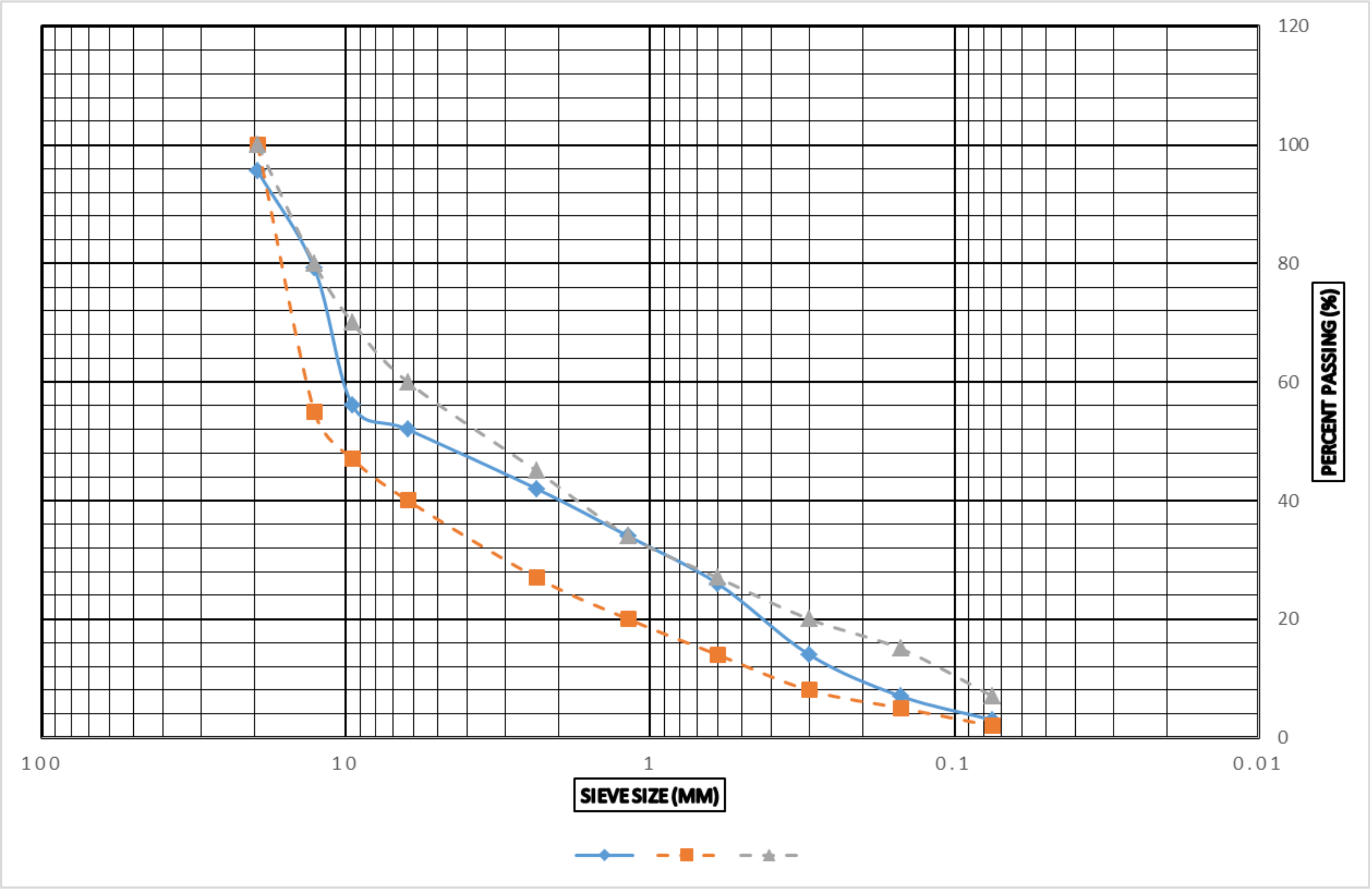

Figure 2: Aggregate Sieve analysis grading envelope

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Table 1: Uniformity Coefficient of Aggregates

	PCF	River sand	Quarry dust	Granite
D_{60} (Diameter at 60% finer)	4.5	3.22	2.27	14.4
D_{10} (Diameter at 10% finer)	0.42	0.24	0.16	6.80
Uniformity coefficient, D_{60}/D_{10}	10.71	13.42	14.19	2.12

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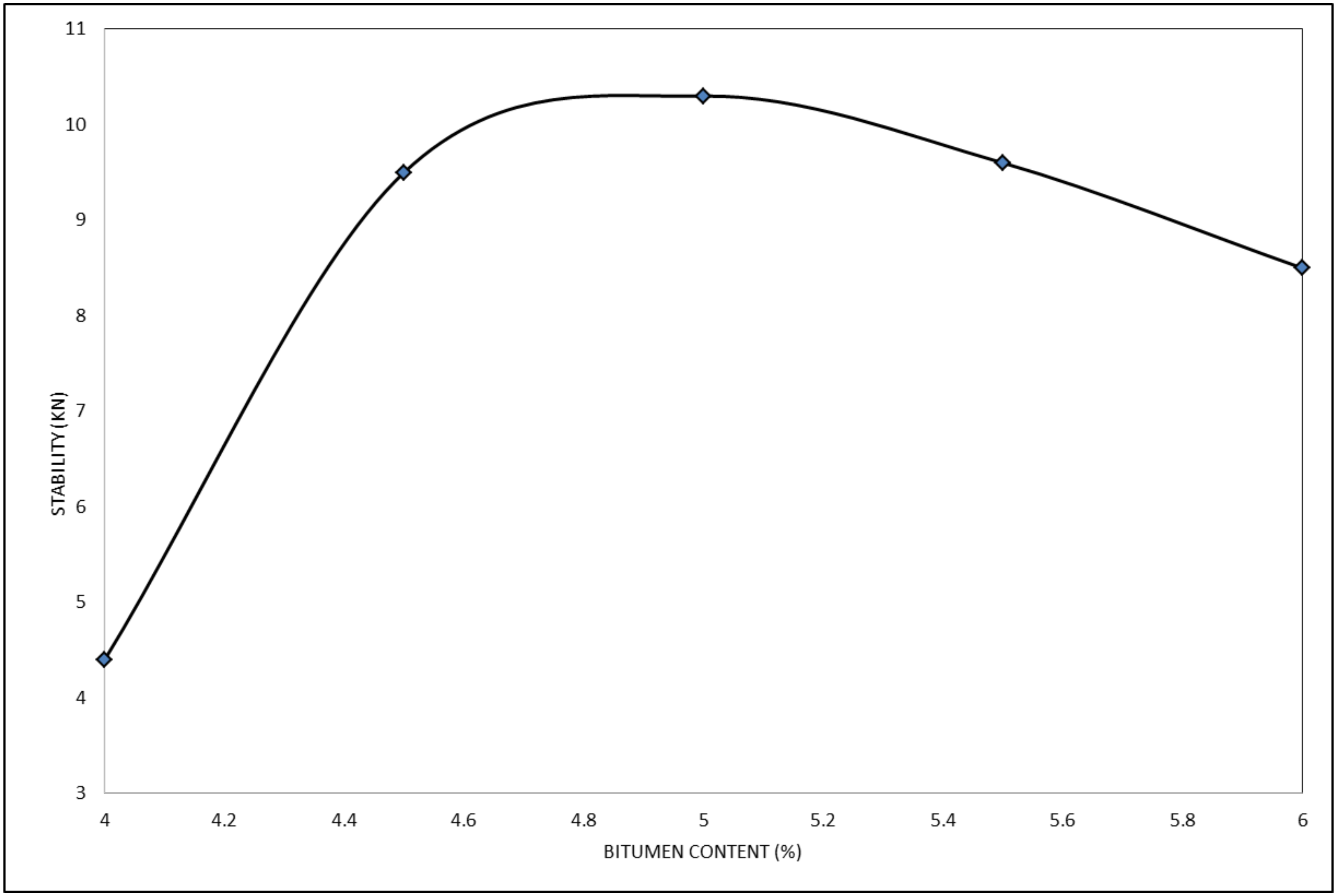

Figure 3: Marshall Stability

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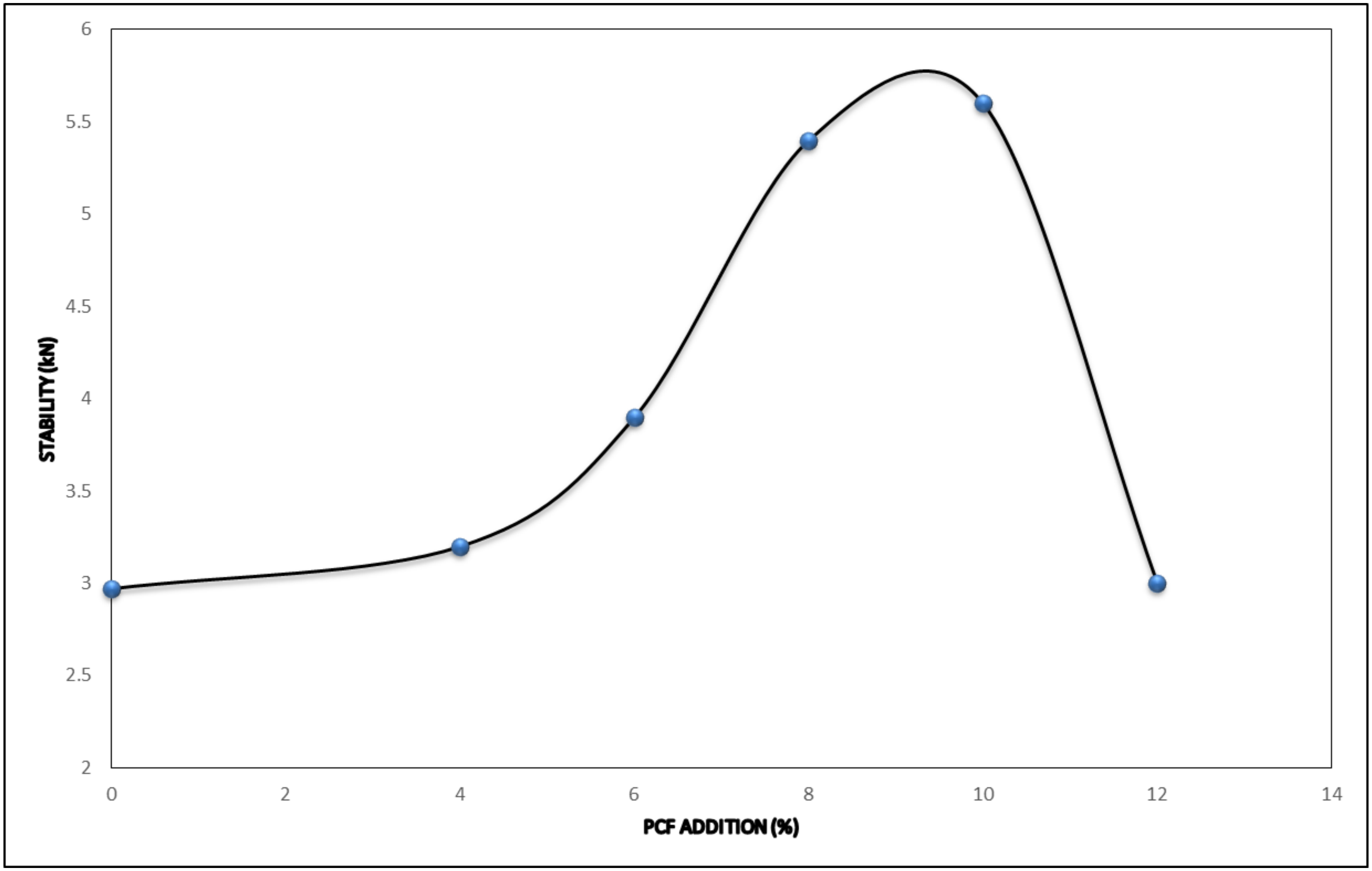

Figure 4: Marshall Stability

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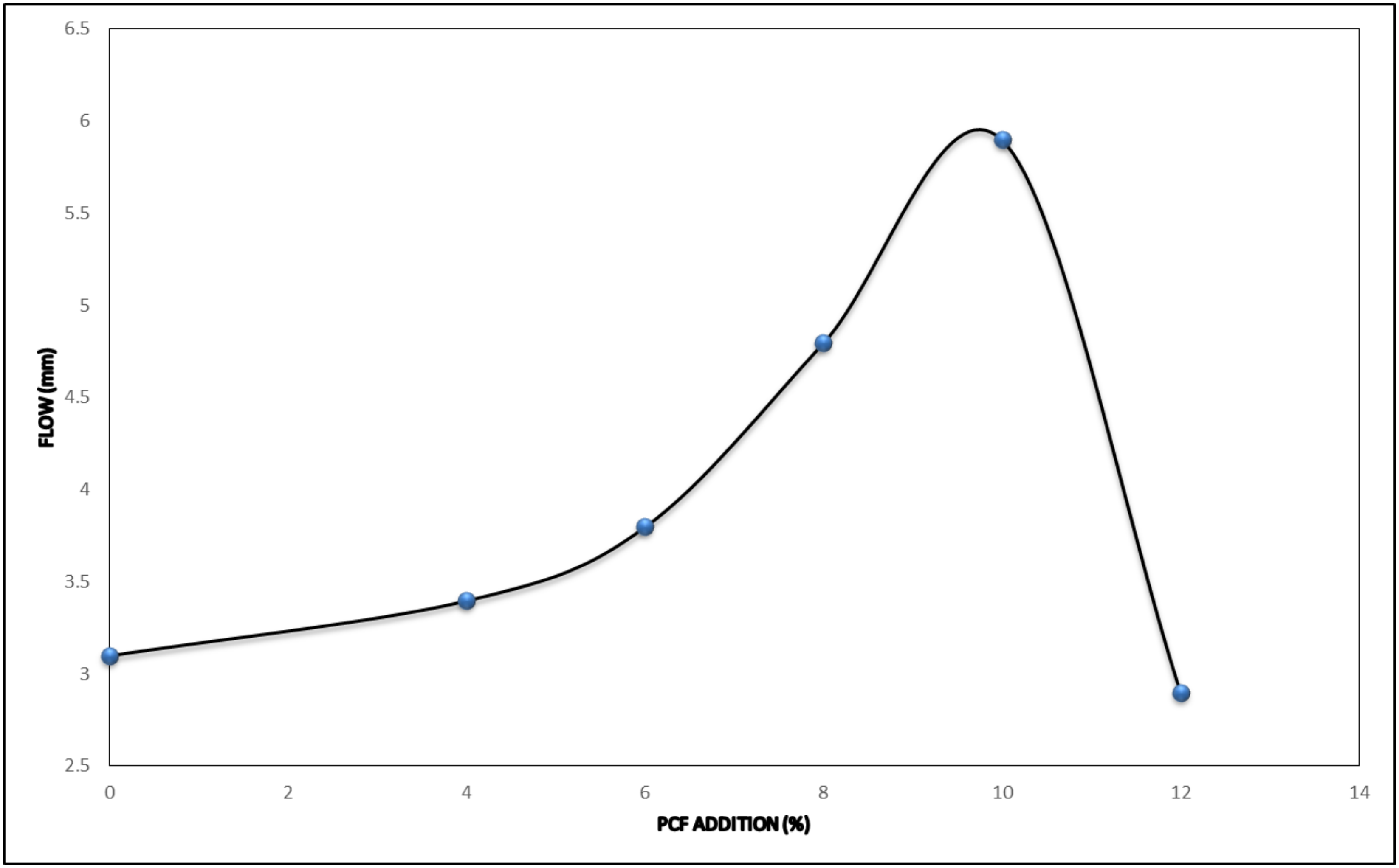

Figure 5: Marshall Flow

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