Fibers Pavement Concrete Proposed for Salang Road-Afghanistan-A review

Propuesta de pavimento de hormigón con fibras para la carretera de Salang, Afganistán: una revisión

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Abstract:

In this paper, an intensive review was made to propose Fibers Pavement Concrete (FPC) for Salang-Road Afghanistan. Moreover, structural properties of FPC were also evaluated and compared with those of Asphalt road. There are various benefits in application of Fiber within rigid pavement. For instance, FPC has longer life and lower maintenance cost in compare with the flexible pavement. In rigid pavement design temperature and thickness are two effective parameters that could widely affect by inclusion of fiber to the total cost of the Salang Road-Project. Different types of fibers with volume fraction optimization which economical and safe are introduced. A concept was adopted to quantify the benefits of adding fiber in terms of extension of the pavement service life and also in terms of reduction in the concrete thickness for the same service life of both reinforced and unreinforced concrete pavement sections. that the use of fibers reduces the thickness of road pavement, enhance the durability and subsequently decreases the overall cost of road construction of Salang rigid pavement.

Keywords: fibers, structural properties, rigid pavements, temperature, Salang-Road.

Resumen:

En este artículo se realizó una revisión intensiva para proponer concreto de pavimento de fibras (FPC) para Salang-Road, Afganistán. Además, también se evaluaron las propiedades estructurales del FPC y se compararon con las de la carretera asfáltica. Existen varios beneficios en la aplicación de fibra dentro de pavimento rígido. Por ejemplo, el FPC tiene una vida más larga y un menor costo de mantenimiento en comparación con el pavimento flexible. En el diseño de pavimento rígido, la temperatura y el espesor son dos parámetros efectivos que podrían afectar ampliamente la inclusión de fibra en el costo total del Proyecto de Carretera Salang. Se introducen diferentes tipos de fibras con optimización de la fracción volumétrica, económicas y seguras. Se adoptó un concepto para cuantificar los beneficios de agregar fibra en términos de extensión de la vida útil del pavimento y también en términos de reducción del espesor del concreto para la misma vida útil de secciones de pavimento de concreto reforzado y no reforzado, pues el uso de fibras reduce el espesor del pavimento de la carretera, mejora la durabilidad y posteriormente disminuye el costo total de la construcción de carreteras con pavimento rígido de Salang.

Palabras claves: fibras, propiedades estructurales, pavimentos rígidos, temperatura, Salang-Road.

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1. INTRODUCTION

Salang Road (SR) is currently the primary mountain pass which is the most direct connections betwyeen the Kabul regions with northern Afghanistan. The pass crosses the Hindu Kush mountains but is now bypassed through the Salang Tunnel, which runs underneath it at a height of about 3,400 m. At least 10,000 vehicles, including cars, buses and trucks cross the SR Pass daily, which serves as lifeline between Kabul and the northern provinces, have been repaired many times over the past decade, but the conditions remain severe as using asphalt and poor maintenance are the main reasons for the degradation of the SR (Malistani & Nejabi, 2019). On the other hand, Asphalts road does not have sufficient durability against snow and humidity. Hence, most of the time Salnang-Road (SR) is under the snow fall and Temperature is under 0 C0. Salang Road several times constructed but due to low temperature and humidity and high rapid load of vehicles destructed and damaged. Thus, many times reconstructed SR by government of Afghanistan but not withstand till design life and damaged in short period of time. To tackle these problems, rigid pavements (FRC) can be constructed.

A country can achieve sustainable and rapid growth in all fields by improving its connectivity and transit systems which connectivity of people to resources by improved transit mechanism results in improved living standards. Thus, the major part of connectivity of any country is through road systems (Achilleos et al, 2011; AL-Kaissi, Daib & Abdull-Hussain, 2016; Hassouna & Jung, 2020; Cervantes & Roesler, 2009). In Afghanistan, all the major road systems are designed as flexible pavements only, because of their ease of construction and less time it takes to be opened to traffic operations. Pavement plays a significant role to improve cost effective and efficient high way and road networks. In structural point of view pavement is categorized in two main group namely flexible (Asphalts) and rigid pavement (Concrete) The major problem with flexible pavements is their design life and high maintenance costs (Fuente-Alonso et al., 2017).

Although the cost of construction of rigid pavements is high, its long life, high load carrying capabilities and low maintenance cost will balance the initial cost aspect (Azimi, 2015; 2017). Recently, many studies are being conducted on different types of fibers which can be used in rigid pavements, thereby reducing its cost and enhancing properties and durability of the mix (Mohsin, Azimi & Namdar, 2014; Azimi et al., 2014). In transportation sector, rigid pavement is an important application of concrete, since using concrete as a surface pavement is more durable than asphalt pavement, requiring less maintenance and having longer life (Malistani & Nejabi, 2019; Lakshmayya & Aditya, 2017; Nobili, Lanzoni & Tarantino, 2013; Celis & Mendoza, 2020). Conventional concrete usually experiences failure caused by the breakdown of the bond between paste and aggregate, and this reduces the flexural strength which is one of the principal factors in concrete pavement design (Ho et al., 2012; Prathipati & Rao, 2020; Chi & Zhang, 2014; Shafigh, Mahmud & Jumaat, 2011; Rana, 2013). Therefore, the enhancement in flexural can be used to improve the performance sections and to reduce the required thickness of the pavement (Guo et al., 2019; Ali, Qureshi & Kurda, 2020; Mohammed, Bakar & Bunnori, 2016).

On the other hand, concrete pavements may undergo rapid deterioration, in the form of micro and macro cracks, fractures and failures, which can cause loss of serviceability and unsafe driving condition (Safdar, Matsumoto & Kakuma, 2016; Jamwal & Singh, 2018; Shakir, Al-Tameemi & Al-Azzawi, 2021). This occurrence is mainly due to the brittle behavior of cement concrete together with its low resistance to fatigue phenomena and its small toughness (Perkins et al.; Ali, Qureshi & Khan, 2020; Bordelon, 2007). However, these detrimental aspects can be mitigated through the adoption of fibers. Indeed, dispersed structural fibers can be added at the mixing stage of concrete in the so-called fiber reinforced concrete (FRC). Many studies have been performed in the last decades concerning the mechanical performance of FRC (Choi, Park & Jung, 2011, Bywalski et al., 2015; Kamel, 2016). It appears that fibers can significantly improve durability, tensile strength and toughness of the cement matrix, preventing the crack opening and growth in concrete members (Akil et al., 2011; Alengaram, Muhit & Jumaat, 2013) and cementitious composites, like cement-treated road materials (Almousawi, 2011). Asphalt pavement has been widely used in express highway for its merits of smooth, comfortable travel, low-noise and so on.

However, early damage of asphalt pavement becomes more and more serious with the continued increasing of axle load and traffic; therefore, asphalt concrete should be modified in some way to promote its pavement performance (Carmona, Aguado & Molins, 2013; Chaallal, Nollet & Perraton, 1998). Among those modifiers of asphalt concrete, fibers have obtained more and more attention for their excellent improvement effects and its merits of simple construction and economic cost. Cement concrete pavement provides durable service life and remarkable applicability for heavy traffic (Deka, Misra & Mohanty, 2013; Hassanpour, Shafigh & Mahmud, 2012). Its purchase being easier than asphalt, cement concrete pavement offers excellent advantages in terms of durability and economic efficiency (Mannan & Ganapathy, 2002; Shafigh, Mahmud & Jumaat, 2011). However, adequate repair of this pavement is harder than asphalt concrete in case of degradation or damage. Different types of fibers, especially steel and synthetic fibers, are commonly used to strengthen the mechanical behavior of concrete, producing good results with numerous properties. In general, tensile, flexural, impact, fatigue and wear strength, deformation capability, load-bearing capacity after cracking, and toughness are significantly improved with the use of fibers in concrete mixes (Teo, Mannan & Kurian, 2006; Zhang, Stang & Li, 2001; Gorkem & Sengoz, 2009; Ramsamooj, 2001; Chen & Huang, 2008; Fitzgerald, 2000; Rahnama, 2009). The main aim is to review the studies which focused on the influence of utilizing fibers in rigid pavement. Also, a comparison of

Figure 1. Salang-Road, Afghanistan

the conventional concrete with the fiber reinforced concrete based on previous researches will be made. This research investigated to quantified advantages of different types of fibers into pavement concrete, in order to consider Fiber Pavement Concrete (FPC) as a replacement of Asphatls road concrete for SR Afghanistan. Here, an attempt is made to reduce the construction cost of rigid pavements by incorporating fiber in rigid pavement concrete of Salang-road of Afghanistan.

2. FIBER ROAD CONCRETE

The pavement may be defined as a relatively stable layer constructed above the natural soil for suitable distribution of wheel load and provides support to the wearing surface (Chen & Huang, 2008; Fitzgerald, 2000). In history, the pavements have been divided into two types; flexible and rigid pavements depending on the way of transferring load to the foundation soil. For flexible pavements, there is a gradual stiffness that increases from the foundation soil to the wearing way, which leads to high stress on the soil because the load is decadent over a relatively small area. On the contrary, in rigid pavements, the stresses on the soil are smaller because the stiffness of the road base is bigger than that of the soil (Rahnama, 2009; Maurer & Gerald, 1989). The main advantages of using Portland Cement Concrete pavement has the durability and the ability to hold the required shape. The durability and serviceability of concrete pavement structures rely on the rate of pavement deterioration. The deterioration of pavement relies on features such as climatic effects, properties of a material, and Vehicular loads characteristics. Cracks in concrete pavements can be seen as a tensile failure (Mahrez, Karim & Katman, 2005; Mahrez, Karim & Katman, 2003). Cracks are developed at different positions in the pavement, in cases where higher tensile stresses are developed in it which is greater than the concrete bending strength (Mahrez, Karim & Katman, 2003; Peltonen, 1991). The PCC is a brittle material that possesses lesser tensile or bending strength and lower induced strain at failure. To solve such a problem, steel reinforcement or bars are incorporated in the concrete structures. Delaying and controlling tensile cracking is the main impact of fiber reinforced concrete. Reinforcing concrete with fiber significantly affects the costs of pavement construction due to decreased thickness requirements, reduced maintenance costs and effort, and therefore longer service life (Huang & White, 1996; Putman & Amirkhanian, 2004; Chen et al., 2004; Echols, 1989). The main purpose of adding steel fiber to the concrete flooring is to modify the cracking mechanism. The cracking system is revised, and ultimately, there is an enhancement in its static and dynamic properties as well as performance at various applications of load. During the previous researches, there have been advances to use discontinuous, randomly ori-

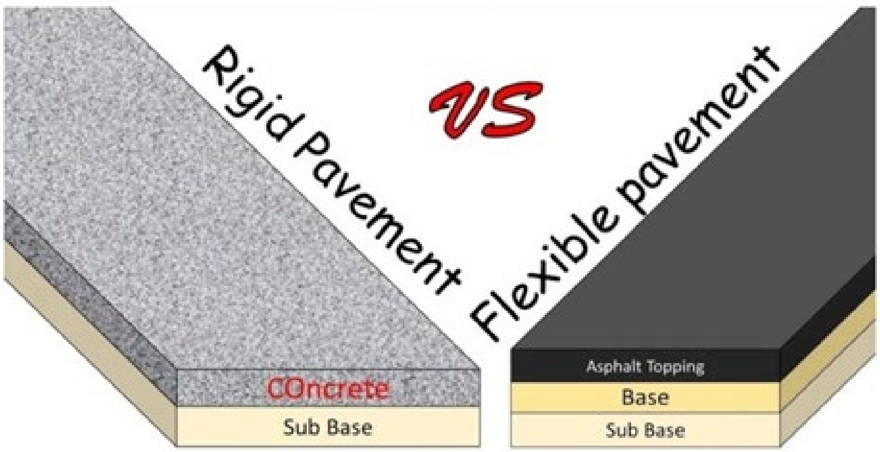

Figure 2. Flexible Pavement Vs Rigid Payment Layers

ented, discrete fibers to overcome these weaknesses (Maurer, Malasheskie, 1989; Abtahi et al., 2008). This is recognized as concrete reinforced with fiber. The adding of fibers into the stiff concrete can enhance the control of growth and propagation of micro cracks as the tensile strain in the concrete increases. The type and percentage of improvement are based on type, size, shape, amount, and strength of fiber (Hejazi et al., 2008; Tapkın et al., 2009; El-Sheikh, Sudol & Daniel, 1990).

3. FIBERS

Amongst the many benefits of fibre inclusion in concrete mixture are increased bond between the matrixes, increased shear, moment and punching resistance, increased dowel effect, reduced crack spacing and crack widths, increased flexural stiffness and ductility (Achilleos et al, 2011,Lakshmayya & Aditya, 2017; Nobili, Lanzoni & Tarantino, 2013; Safdar, Matsumoto & Kakuma, 2016). Different types of fibres have been used in concrete mixture such as glass fiber, steel fiber, synthetic fibre and natural fibre (AL-Kaissi, Daib & Abdull-Hussain, 2016; Ho et al., 2012; Prathipati & Rao, 2020).

i. Glass fibre is available in either continuous or chopped lengths. Fiber lengths between 25 to 35-mm lengths are used in concrete mixture. Glass fibre has high tensile strength up to 4 GPa and elastic modulus up to 80 GPa but it has brittle stress-strain characteristics, and it has an elongation up to 4.8 %.

Figure 3. Glass Fiber

ii. Steel fibres are commonly used within concrete structures. The earlier version of fibres used were round and smooth, and the wire was cut or chopped into the required lengths but modern fibres have either rough surfaces, hooked ends or are crimped. Typically steel fibres have the equivalent diameter ranging from 0.15 mm to 2 mm and lengths from 7 to 75 mm. Aspect ratio is defined as the ratio between fibre length and its equivalent diameter, and it varies from 20 to 100. Steel fibres have high tensile strength up to 2 GPa and modulus of elasticity 200 GPa.

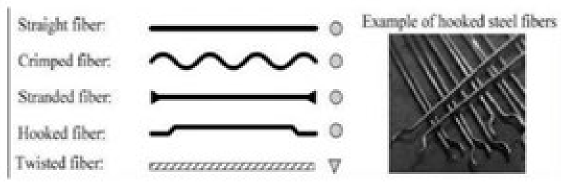

Figure 4. Types of Steel Fibers

iii. Synthetic fibres are man-made fibres resulting from development in the petrochemical and textile industries. Fiber types that have been used in concrete mixtures include acrylic, aramid, carbon, nylon, polyester, polyethylene and polypropylene. Table1 summarises the range of physical properties of commonly used synthetic fibres.

Figure 5. Synthetic fibre (Azimi et al., 2014)

Table 1. Synthetic fibre types and properties [10]

Fibre type	Diameter (µm)	Density	Tensile Strength (MPa)	Elastic Modulus (GPa)	Ultimate Elongation (%)
Acrylic	13-104	1.16-1.18	270-1000	14-19	7.5-50
Aramid	12	1.44	2900	60-115	4.4
Carbon	8-18	1.6-1.7	2500-3000	380-480	0.5-0.7
Nylon	23	1.14	970	5	20
Polyester	20	1.34-1.39	230-1100	17	12-150
Polyethylene	25-1000	0.92-0.96	75-590	5	3-80
Polypropylene	-	0.9-0.91	140-700	3.5-4.8	15

Table 2. Literature Survey

Author	Year	Study Topic	Result
Constantia Achilleos et al	2011	Proportioning of Steel Fiber Reinforced Concrete Mixes for Pavement Construction and Their Impact on Environment and Cost	SFRC Pavement design is a good sustainable alternative instead of asphalts for the road construction industry, both in the economic and environmental aspect. Steel fibers significantly improve the impact resistance of concrete making it a suitable material for structures subjected to impact loads.
Zainab Kaissi et all	2016	EXPERIMENTAL AND NUMERICAL ANALYSIS OF STEEL FIBER REINFORCED CONCRETE PAVEMENT	Comparison between horizontal tensile stress and strain at bottom of concrete pavement for (0.0, 0.4, and 0.8) % volume fraction of steel fiber content show that as steel fiber content increase the ability of concrete pavement to withstand higher magnitudes of stress and strain without deterioration
Fady M. A. Hassouna and Yeon Woo Jung	2020	Developing a Higher Performance and Less Thickness Concrete Pavement: Using a Nonconventional Concrete Mixture	The results showed that the new concrete mixture could achieve an increase in flexural strength between 48.9% and 50.5% compared to normal concrete mixture without steel fibers and steel slag, with minimum acceptable workability, and therefore, the required pavement thickness could be decreased by more than 24 %.
Cervantes, V., & Roesler, J.	2009	PERFORMANCE OF CONCRETE PAVEMENTS WITH OPTIMIZED SLAB GEOMETRY	Concrete slabs on an asphalt base withstand much more ESAL than concrete of the same thickness on a granular base. The breaking capacity of 3.5-inch concrete slabs varied with the hardness of the soil. In all cases, for the 3.5-inch slab, structural fibers provided longer fatigue life, increased durability, and higher transverse load transfer capability than conventional concrete slabs.
Fuente-Alonso	2017	Performance of fiber-reinforced EAF slag concrete for use in pavements	Fiber-reinforced concrete pavement gave satisfactory results in terms of strength as measured by energy absorption at break in compression and tensile tests on normal and FRC specimens. Resistance to impact and abrasion showed better results in mixtures containing EAFS as aggregate than in mixtures with natural aggregates.

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Lakshmayya	2017	DESIGN OF RIGID PAVEMENT AND ITS COSTBENEFIT ANALYSIS BY USAGE OF VITRIFIED POLISH WASTE AND RECRON POLYESTER FIBRE	It was found that the optimum value for adding VPW to the M40 construction mix is 15 %, at which point the compressive, bending and splitting tensile strengths reach their maximum values. At 15 degrees from VPW to M40, the compressive, bending and splitting tensile strengths increased within 28 days by 11.54 %, 36.92 % and 14.41 % respectively compared to conventional mixing.
Oliver C. Celis1 and Catalino N. Mendoza	2020	Experimental investigation and monitoring of a polypropylene-based fiber reinforced concrete road pavement	In this work, basic design guidelines for a polypropylene-based fiber reinforced concrete road pavement are presented. Monitoring was carried out under actual traffic conditions, as the test section was opened to the public long before the full project was developed, taking advantage of the pre-existing road network.
Oliver C. Celis1 and Catalino N. Mendoza	2020	QUANTITATIVE ANALYSIS OF THE BEHAVIOR OF RAMIE FIBERREINFORCED CONCRETE FOR RIGID PAVEMENT	It was found that maximum compressive strength of Ramie fiber reinforced concrete for stiff pavement is 34.93 MPa with a maximum fiber content of 1 %, and for tensile and flexural stresses, the maximum values are 2.98, MPa and 5.99 MPa respectively. The slab thickness reduced by 23 %.
Turatsinze, A., Hameed	2012	Effects of rubber aggregates from grinded used tyres on the concrete resistance to cracking	Brittleness of the concrete composite is decreased by the addition of rubber aggregates. it is almost zero for a concrete composite containing 40 % rubber aggregate content. Results obtained by applying AE technique showed that before the peak load, there is a micro-cracking zone at the tip of the notch while from the peak load. The Elastic Quality Index of rubberized composite decreases with the increase of temperature.
Bentur and Mindess	2006	Effect of hybrid steel fibers (short and long fiber) on the toughness and ductility of the concrete	The results showed an improved toughness and ductility of the pavement because short fibers tie the micro-cracks this resulted in enhancing the flexural strength and the long fibers minimized the propagating of macro cracks.
Eswari S. et al	2008	Studied the ductility performance of HFRC	The fibers enhanced the ductility of HFRC compared with non-fibrous RC
Thanon and Ramli	2011	Discussed the use of steel fiber with a different percent of volume in concrete as a hybrid steel and palm fibers on the mechanical properties of mixure	The mechanical properties of concrete improved with the increase of volume percent of the fiber and the optimal proportion of steel fiber is 1.5 %. The increase in toughness indicates high strength concrete when the usage of the hybrid fiber of 1.5 % steel and 0.5 % palm fibers
Rana	2013	Explore the effect of steel fiber on the concrete flexural strength and compared it with M25 grade concrete	The rise in steel fiber amount in the mix led to a significant rise in flexural strength. Consequently, flexural strength was increased by about 1.1 % compared with M25 grade concrete.
Mehul and Patel	2013	The impact of using different ratios of polypropylene fibers on the high strength concrete properties	The result showed that the flexural, tensile, and shear strength were notably increased. the fiber impact on plastic shrinkage cracking is considered

Sinha	2014	To calculate the optimal amount of steel fiber added to the mixture for economic construction of pavement compare to normal concrete pavement	Compared to traditional concrete, SFRC is a significant indication of composite material as the pavement thickness is reduced without affecting load-carrying capability and cost-effective technology
Jamwal and Sing	2018	Effect of different percentage of glass fiber to design the slab thickness of (PQC) using achieved flexural strength of the concrete mixture	The study showed that the high split tensile and flexural strength values of the concrete lead to enhance the load-carrying capability and produce greater predictable life. The addition of glass fiber to concrete lead to reduce the slab thickness
Hadeel M. Shakir	2021	A review on hybrid fiber reinforced concrete pavements technology	The use of various kinds of fibers in reinforced concrete pavements is essential to improve performance-related properties. Fibers are used individually or simultaneously (hybrid) in concrete pavements and are obtainable in a variety of shapes, lengths, sizes, and depths. It is obvious from past findings that fiber hybridization improves the properties of concrete better than mono fibers. It can be concluded that using hybridization in reinforced concrete pavement allows to reduce the thickness up to 30% by the improvement of compressive and tensile strengths.
Dr. Steven W. Perkins	2005	Development of Design Methods for Geosynthetic Reinforced Flexible Pavements	Significant improvement in terms of the number of traffic passes needed to reach a specified pavement surface deformation was observed for pavements constructed over relatively weak subgrades. The method has been formulated to be generic such that properties of the reinforcement established from different test methods are used as input.
Babar Ali	2020	Flexural behavior of glass fiber-reinforced recycled aggregate concrete and its impact on the cost and carbon footprint of concrete pavement	The results show that the application of glass fiber-concrete in highway concrete pavements is economical and environmentally feasible than choosing the plain concrete for the provision of a same service facility. Cost of pavement (CP) per square meter (USD/m^2) was evaluated and compared for different mixes. Compared to control concrete, 100 %CWA concrete yields 7% lesser CP value. Whereas 0.25 % GF incorporation leads to minimum CP values at all levels of CWA. Despite a high cost per unit volume, GFreinforced concretes at 0.25% fiber volume yield 21 % cheaper pavement than that of the control concrete.
Urbana, Illinois	2005	FRACTURE BEHAVIOR OF CONCRETE MATERIALS FOR RIGID PAVEMENT SYSTEMS	Specifically, functionally graded concrete materials (FGCM) for two lift rigid pavement construction, UTW composite material behavior, and fiber-reinforced concrete (FRC) pavements and the evaluation of mixture design selection to assist engineers in optimizing field performance.

S. Y. CHOI et al	2011	A Study on the Shrinkage Control of Fiber Reinforced Concrete Pavement	Three types of macro fibers with length longer than 30 mm and small aspect ratio together with micro nylon fibers with length of 12 mm and aspect ratio larger than 1000 are selected for the tests. Both reinforcement with a single type of fiber and hybrid reinforcement involving micro and macro fibers were executed, and the fiber volume ratio was set to 0.2 to 0.3 % of the concrete pavement mix.
Bywalski et al	2014	Influence of steel fibers addition on mechanical and selected rheological properties of steel fibre high-strength reinforced concrete	The percentage of total shrinkage distortion depends on the content of fibers and reduced, since the content has been increased. For each type of fibers, depending on their shape, a length and a slender ratio, there is an optimal level of structural gain, which may not be exceeded due to the process ability of the concrete mix.
M. A. Kame	2016	Quantification of Benefits of Steel Fiber Reinforcement for Rigid Pavement 2016	The incorporation of steel fibers to PCC results in an appreciable increase in compressive strength for different curing times, the increase has ranged from 10 % to 45 %. Flexural strength has improved up to 60 % as compared to PCC. The dynamic modulus of elasticity determined through ultrasonic testing on different concrete specimens has also got an increase of 25 % with a steel fiber content of 8 % by cement weight.
Yating Zhang et al	2014	Research on the behavior of rigid pavement of basalt fiber reinforced dowel bar under the condition of variable temperature	The range ability of temperature decreases with the enhancement of depth, and the temperature of pavement surface will be less than that of the road interior while heat release arises at the surface with a weakness of solar radiation. Impact analysis according to cement concrete pavement temperature stress containing basalt fiber reinforced dowel bar under different surface thickness shows that dowel bar has not occurred plastic deformation and bending strength meet the requirements.
Chih-Ta Tsai et al	2010	Use of high performance concrete on rigid pavement construction for exclusive bus lanes	This study incorporated the densified mixture design algorithm (DMDA) into the mixture design of HPC and HPSFRC in light of the critical requirements of constructing the rigid pavement in the bus stops of the exclusive bus lanes. The properties of HPC and HPSFRC designed can meet the design requirements, including the compressive strength at 3, 28, and 56 days, the flexural strength at 28 and 56 days, the workability including slump, slump flow, flow time, durability in terms of resistivity and charge passed.

4. RESULTS AND DISCUSSION

The type of fiber and its volume fraction has a considerable effect on the properties of FRC. The amount of fibre can be classified as a function of their fiber volume fraction, low fibre volume fraction 1 %, reasonable fibre volume fraction between 1 % and 2 % whilst high fibre volume fraction greater than 2 %. Fibre contents in excess of 2 % by volume fraction results in poor workability. Figure 2.3 illustrates the behaviour of fiber into the matrix (Azimi, 2017; Mohsin, Azimi & Namdar, 2014). Martin et al. (2008) observed that the behaviour of plain concrete is brittle, concrete with insufficient amount of fiber behaves quasi-brittle and concrete with sufficient amount of fibres behaves multiple cracking (strain-hardening).

i. Brittle behaviour of concrete is observed when there is no fibres and steel inside the concrete. This is because, the concrete loses its tensile strength immediately after formation of first crack.

ii. The quasi-brittle behaviour of concrete describes concrete that starts softening immediately after first cracking load. However, quasi-brittle behaviour of concrete still capable of transferring some reduced amount of stress which gradually decreases with increasing crack opening.

iii. Multiple cracks (strain-hardening) occur when fibres within the matrix are capable of arresting the further opening of cracks by fiber bridging mechanism and inhibiting cracks growth. These mechanisms in turn cause the increase in the number of cracks whilst decreasing the spacing cracks.

Plain concrete pavements have low tensile strength and strain capacity, however these structural characteristics are improved by fibre addition, allowing reduction of the pavement layer thickness. This improvement can be significant and depends on fibre characteristics and volume fraction and fiber influence to delay and control the tensile cracking of concrete (Munn, 1989; Echols, 1989). Therefore, it is found to have significant impact on the pavement cost due to reduced thickness requirements, less maintenance costs and longer useful life and comparing with the life cycle of an asphalt road, SFRC pavements have been reported to last twice as long. The largest volume application of SFRC has been in airport pavements due to high and damaging loads (Maurer & Arellano, 1987; Putman, 2004). Steel fibers significantly improve the impact resistance of concrete making it a suitable material for structures subjected to impact loads. SFRC pavement eliminates spring load restrictions. It does not rut, washboard or shove as in asphalt roadways; and it provides fuel savings for heavy vehicles versus asphalt pavements [New Jersey Division of Highways, 1976; Serfass & Samanos, 1996). All the above factors suggest that SFRC pavements are the most beneficial pavement type from an engineering and economical prospective. On the other hand, the current high cost of steel fibres in many regions may not justify their use, despite the lower life cycle costs achieved due to reduced maintenance requirements (Jenq, Liaw, C & Lieu, 1993; Simpson & Mahboub, 1994).

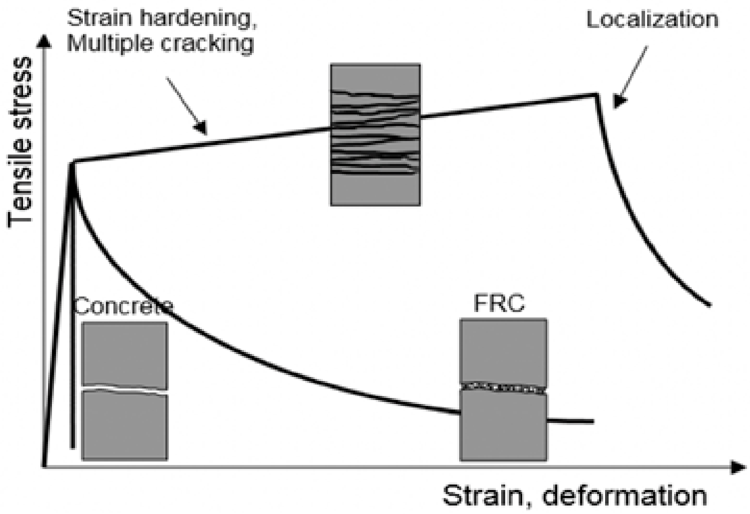

Figure 6. Typical stress-strain curves for concrete, concrete with insufficient amount of fiber and concrete with sufficient amount of fibres (Fuente-Alonso et al., 2017)

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Cracking in the concrete pavement is the major cause of such disadvantages and the demand of repair on road sites is growing every day. This emphasizes the urgency to secure technologies for the control of early and long-term cracking. Rigid Pavements are made of Portland Cement Concrete (PCC). It serves out two aims, to maintain a durable surface with comfortable driving for vehicles. The second purpose is to decrease the stresses on the layers of pavement beneath the surface such as subbase and subgrade (Chen, Chung & Fu; Song, Hwang & Sheu, 2005). Concrete is considered a weak material in resisting tensile stresses. Therefore, when low tensile stresses are applied, rigid pavement begins to crack effortlessly. In concrete pavement, the usage of different kinds of fiber reinforcement could be an effective technique to improve these properties. Numerous kinds of fibers are utilized in the concrete pavement to behave as an alternative to ordinary reinforcement. They may differ in material like steel or plastic and could be in many shapes, and dimensions (Choi & Yuan, 2005,Alhozaimy, Soroushian & Mirza, 1996). The addition of fibers is during the mixing when the concrete is still fresh. The incorporation of different sorts of fibers could be a significant step in diminishing the cracks and achieving a higher performance of concrete. Two kinds of fibers or even more than two can be combined to achieve a mixture that produces profits for each type of fiber in this composite as hybrid fiber (Noumowe, 2005; Singh, Shukla & Brown, 2004). The reinforcement of concrete pavements with steel fibers may be considered as a good economical alternative. Not only, is the reduction of the construction costs expected but also, in terms of saving of natural resources (Einsfeld & Velasco, 2006).

5. CONCLUSIONS

It can be concluded; different types of fiber showed good compatibility in order to improve the structure properties of Concrete-Road pavement. In addition, fibres were efficient for improving the tensile strength of PC to prevent from diagonal-tension cracking and caused to enhance the durability and service life of Road pavement structure. The concrete rigid pavement has low resisting the tensile stress and, cracks occur simply under the effect of Vehicles load. The use of various kinds of fibers in reinforced concrete pavements is more effective to improve road structure properties. The main conclusions observed based on previously studied are:

1. It is highly recommended to use fibre with an adequate amount into RPC of Salang for producing economical RP structure. Thus it was indicated that the use of fiber-concrete in highway concrete pavements is economical and environmentally feasible than choosing the Asphalts-Road for the provision of a same service facility, the required pavement thickness could be decreased by more than 24 %.

2. It is obvious from past findings that fiber hybridization improves the properties of concrete, the incorporation of fibers into the concrete led to an increase in the cost of the structure, but this cost increase is not an actual problem because the use of fibers in a mixture improves the durability of rigid pavement concrete.

3. Polymeric fibers such as polyester or polypropylene have proven cost-effective and corrosion resistant but they gave lower mechanical behavior than steel fibers in concrete and hybridization in reinforced concrete pavement allows to reduce the thickness up to 30 % by the improvement of compressive and tensile strengths.

4. An increase in the mechanical properties of concrete such as compressive strength, split tensile strength and flexural strength was caused by the addition of fibers to the concrete mixes but compressive strength of normal strength fibrous concrete is

comparatively scarcely affected by the presence of fibers compared to the tensile strength.

5. The novel concept behind this study is to prevent from shrinkage and expansion of concrete against temperature changes, which causes to increases the design life road pavement concrete.

6. ACKNOWLEDGMENT

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