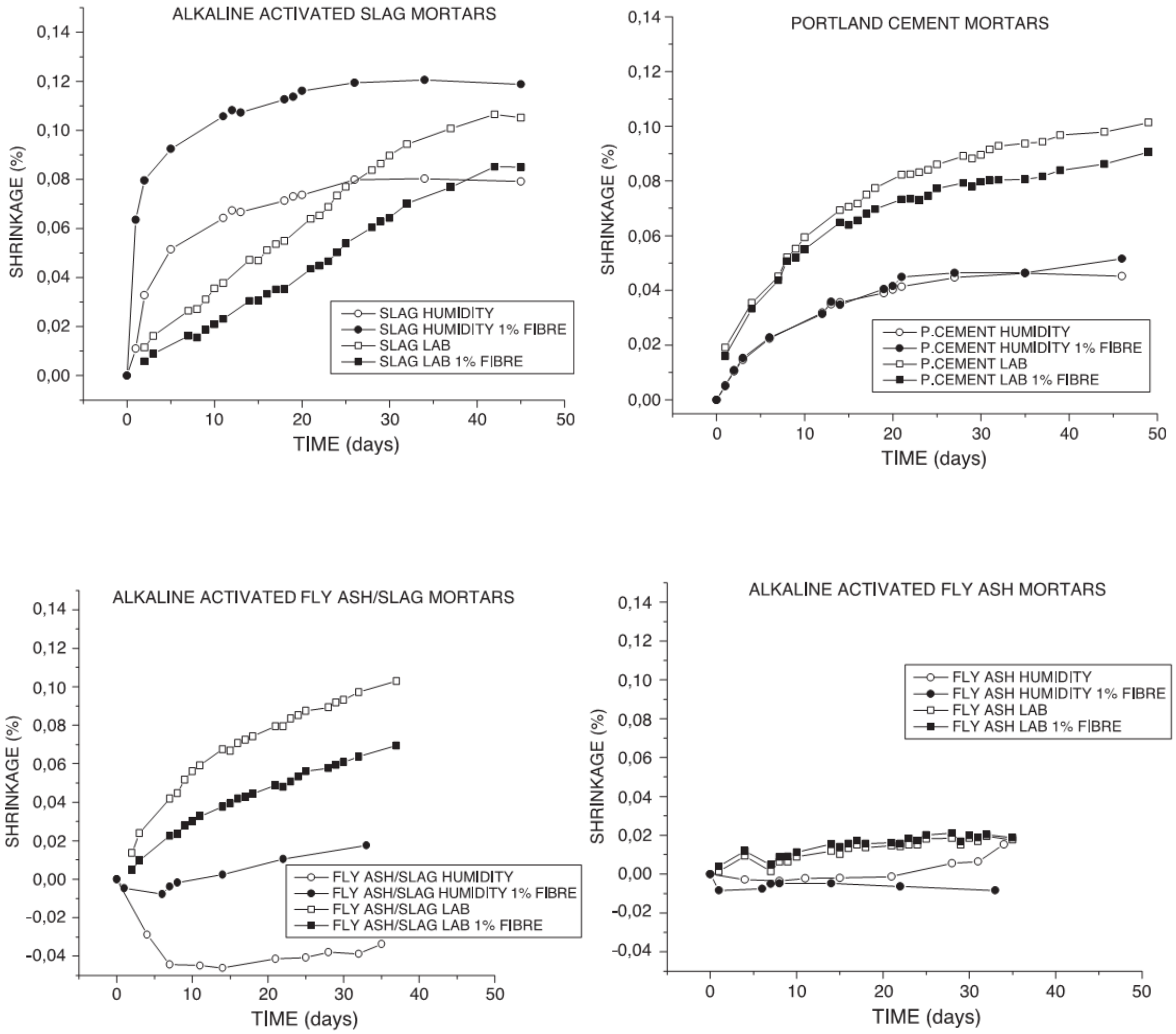
CHAPTER – 3

LITERATURE REVIEW

1. **Puertas, F. [1]** investigated the mechanical and durable behavior of alkaline cement mortars reinforced with polypropylene fibers. Three different alkaline matrices were used: (a) granulated blast furnace slag activated with water glass (Na_2SiO_3+NaOH) with a concentration of 4% Na_2O by mass of slag and cured at room temperature, (b) aluminosilicate fly ash activated with 8M NaOH and cured at 85^0C during the first 24 h and (c) 50% fly ash+50% slag activated with 8M NaOH solution at room temperature. In the mechanical tests (flexural and compressive strengths), two different dosages of fibers were used: 0.5% and 1% by mortar volume. Shrinkage tests according to ASTM C 806-87 standard with (1%) and without fibers were also carried out. The durability tests carried out were freeze/thaw and wet/dry cycles. In these tests, the dosage of fiber was 0.5% by mortar volume. The results obtained show that the nature of the matrix is the most important factor to strength development, more than fiber presence and content amount. The results also showed that polypropylene fibers induced only slight modifications in the mechanical strengths. The presence of fibers reduced the workability, which affected the compaction of the mortar. In activated mortars, the presence of polypropylene fibers reduced the elastic modulus. The polypropylene fibers having low modulus of elasticity and get easily deformed and thus reduced the compatibility of the material. Addition of fibers caused reduction in shrinkage. The presence of fibers didn't show any increase in stability against freezing and thawing. Fibers provided an improved resistance to fracture in all mortars.



Shrinkage versus Time- Influence of curing conditions

2. **Song, P.S. [2]** compared the strength potential of nylon fibers reinforced concrete and that of polypropylene fiber reinforced concrete, at a fiber content of 0.6 kg/m^3. The compressive and splitting tensile strengths and modulus of rupture (MOR) of the nylon fiber concrete improved by 6.3%, 6.7%, and 4.3%, respectively, over those of the polypropylene fiber concrete. On the impact resistance, the first-crack and failure strengths and the percentage increase in the post first-crack blows improved more for the nylon fiber concrete than for its polypropylene counterpart. In addition, the shrinkage crack reduction potential also improved more for the nylon-fiber-reinforced mortar. The above-listed improvements stemmed from the nylon fibers registering a higher tensile strength and possibly due to its better distribution in concrete. The nylon fiber reinforced concrete clearly outperformed its polypropylene companion in the upgrading of compressive and tensile splitting strengths, MOR, and impact resistance. The outperforming arose from the higher tensile strength of nylon fibers and probably the better distribution of fibers through the concrete mass.

3. **Zeiml M. [3]** reported the results of permeability tests on normal strength in-situ concrete without and with polypropylene fibers (1.5 kg/m^3) identifying permeability as the parameter with the greatest influence on spalling. The values for the permeability, which were obtained for concrete pre-heated to different temperature levels, were related to the pore structure, accessible by mercury-intrusion-porosimetry (MIP) tests. The considered concrete was prepared under on-site conditions, accounting for the workability and densification when casting at the construction site. In order to illustrate the effect of the permeability of concrete with and without PP-fibers on spalling, which was experienced during the aforementioned research project, a finite-element analysis, taking the coupling between heat and mass transport into account, was performed. The so-obtained

results provided insight into the risk of spalling of concrete with varying amount of PP-fibers. Based on the results obtained from large-scale fire experiments conclusions were drawn that for pre-heating temperatures lower than 140 °C, the permeability of concrete with 1.5 kg/m^3 PP-fibers was three to four times larger than the permeability of concrete without fibers with decreasing difference for increasing temperature. While the values for the total pore volume, which showed no distinct difference between concrete with and without PP-fibers, could not explain the observed difference, the pore volume within the pore radii $10^3 \leq r \leq 10^5$ nm was considerably larger for concrete with PP-fibers compared to concrete without PP fibers. For temperatures between 140 and 200 °C, the difference between the permeability of concrete with and without PP-fibers increased, reaching again a factor of four. Thus, in case of the tested in-situ concrete, the effect of melting of PP-fibers had equal impact as the difference in the low temperature permeability.

4. **Banthia, N. [4]** discussed the influence of various variables of fiber such as diameter, length and geometry on plastic shrinkage. A test program was carried out to understand the influence of these variables. Four commercially available polypropylene fibers were investigated at dosage rates varying from 0.1% to 0.3%. A recently developed technique of plastic shrinkage testing using a fully bonded overlay was employed. Results indicated that while polypropylene fibers are highly effective in controlling plastic shrinkage cracking in concrete, a finer fiber is more effective than a coarser one, and a longer fiber is more effective than a shorter one. Fibers reduce the total crack area, maximum crack width and the number of cracks. As fiber volume was increased, effectiveness of fiber reinforcement increased. Longer and low denier fibers were more effective in reducing crack areas and crack widths. Also, fibrillated fibers were found to be more effective in controlling shrinkage cracking than their comparable monofilament counterparts.

5. Allan, M. L. investigated the Strength and durability of polypropylene fiber reinforced grouts. Fibrillated polypropylene fibers were added to cementitious grouts to determine whether improved mechanical properties and durability could be achieved. The grouts were studied for suitability as subsurface containment barriers around stabilized hazardous waste landfills. Strength, wet-dry and freeze-thaw durability and shrinkage crack control were investigated. Fibers added at volume fractions of 0.1% and 0.2% were found to reduce crack widths of restrained shrinkage specimens by bridging action. Compressive and flexural strengths were not consistently affected by incorporation of fibers; however, there was significant improvement in ductility. Fibers did not significantly change the residual compressive strength of air entrained grouts subjected to freeze-thaw cycles.

6. Segre, N. [6] investigated the stability of polypropylene fibers in environments aggressive to cement based materials. Isotactic polypropylene (PPi) fibers were left in NaOH, H_2SO_4, synthetic seawater, and cement-with-water solutions at different temperatures and exposure times. Infrared microspectroscopy was used to follow the formation of degradation products. Cement-with-water proved to be the most aggressive bath for the fibers, causing marked oxidation after 100 days exposure; also, the molecular weight of PPi increased as was determined by viscosimetry. Mortar test specimens containing PPi fibers and exposed to CO_2, synthetic seawater, and $MgSO_4$ 0.25M showed a decrease in compressive strength after 260 days. The compressive strength of mortar test specimens containing 0.75 kg per m^3 of PPi fibers irradiated with ultraviolet radiation was roughly 10% lower than that of the control specimen, after only 60 days in water.

7. Lamontagne, A. [7] discussed the influence of polypropylene fibers and aggregate grading on the properties of dry-mix shotcrete. The test results indicated that the use of polypropylene fibers in dry-mix shotcretes made with type 30 cement or type 10 cement with silica fume did not significantly modify any of the properties that were evaluated, i.e. compressive strength, toughness, drying shrinkage, chloride ion permeability, and deicer salt scaling resistance. The results also indicated that it is possible to add up to 4 kg/m^3 of these fibers without any negative effect on the properties of the hardened concrete. The results of the tests further showed that the grading of the aggregates did not have a very large influence on any of the properties that were measured, although the use of coarser sand and an increase in the proportion of the coarse aggregate was found to improve the deicer salt scaling resistance.

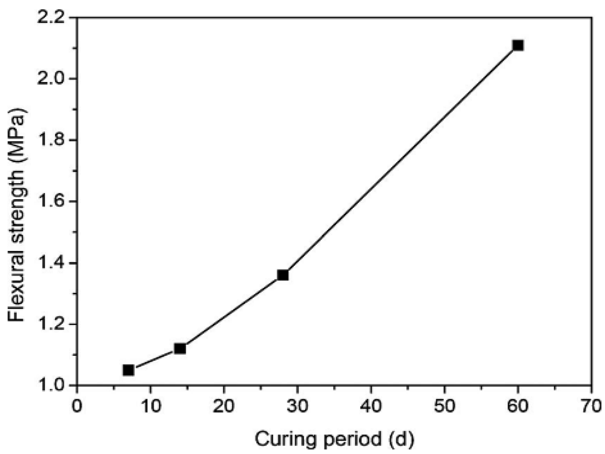
8. Abdul-Hamid J. Al-Tayyib [8] discussed the effect of polypropylene fiber reinforcement in retarding the corrosion of reinforcing steel in concrete, as a result of improving the durability performance of the concrete embedding the steel reinforcement. Reinforced concrete slabs of different water-cement ratios of 0.45, 0.55 and 0.65, made with and without polypropylene fibers, were subjected to severe corrosion initiating conditions and their resistance to corrosion was monitored for a period of more than 7 months. The effect of adding polypropylene fibers was also studied on some properties of concrete that closely relate to corrosion of reinforcing steel. These included electrical resistivity, water absorption, and permeability of concrete. The results showed that the polypropylene fiber reinforcement has no noticeable effect in retarding the corrosion of reinforcing steel in concrete. The results of electrical resistivity, water absorption, and permeability tests showed that there is no significant improvement due to inclusion of polypropylene fibers.

9. Rodezno, M. C. [9] carried out an experimental study to evaluate the engineering properties of four different concrete mixtures: a control mixture with no fibers and mixtures with polypropylene fibers using the following dosages: 3, 5 and 8 lb/yd^3. Various samples were collected during the construction and tested for compressive strength, flexural strength, and toughness using cylindrical, prismatic and round panel specimens. It was concluded that that effect of the addition of fibers was best captured using the round panel test. Another conclusion drawn was that the use of 5 lb/yd^3 fiber dosage had the best value added benefit to the mixture.

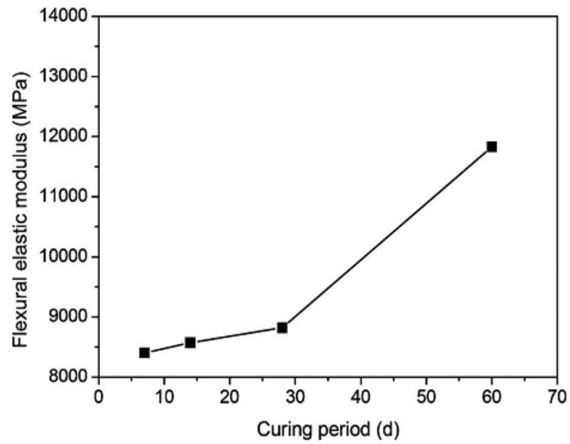
10. Bo Wu [10] investigated the creep Behavior of High-Strength Concrete with Polypropylene Fibers at Elevated Temperatures**.** Experimental studies were conducted to examine the creep behavior of high-strength concrete (HSC) with polypropylene fibers of 3 kg/m^3 when exposed to elevated temperatures. Various types of heating and loading schemes were considered, including transient temperature and stepwise loading points. Tests were carried out at temperatures up to 700^{0}C and a stress ratio up to 0.6. HSC with PP fibers performed better than normal-strength concrete at temperatures below 500^{0}C and showed an obvious increase in creep behavior at 700^{0}C. At the same stress ratio and duration of 120 minutes, the creep strain developed at 700^{0}C was approximately 10 times more than that developed at 500^{0}C. There was no abrupt change in creep behavior at or approximately 2200^{0}C when the PP fibers evaporated. It is likely that the markedly different responses at 700^{0}C were related to the change in the microstructure of HSC at high temperatures. On increasing the stress ratio at constant temperature an abrupt increase in creep strain rate was observed. HSC with PP fibers showed a large transient creep strain, and the phenomenon became obvious at higher temperatures.

11. Attom, M. F. [11] reported the effects of Polypropylene Fibers on the Shear Strength of Sandy Soil. A sandy soil was obtained from a depth of 40 cm from the natural ground surface around American University of Sharjah. Two types of polypropylene fibers; one highly flexible with flat profile and the other with relatively high stiffness and crimpled profile were used in this study with four different aspect ratios (L/D) for each type. The initial physical properties of the sand such as specific gravity, angle of internal friction and shear strength were obtained in accordance with American Standard for Testing and Materials (ASTM). The sandy soils were mixed with the two types of fibers at different percentages by dry weight of the sand and four different aspect ratios. The test results of the study showed that the shear strength of the sand increased with increase in the flexible flat profile fibers content. Also it was noticed that by increasing the aspect ratio of the flexible flat profile the angle of internal friction and the shear strength increased. The crimpled profile fiber increased the shear strength of the sand under high normal load and showed small or no effect on shear strength of the sand at low aspect ratio under low normal load. It was also observed that the ductility of the sand increased by adding the two types of fibers.

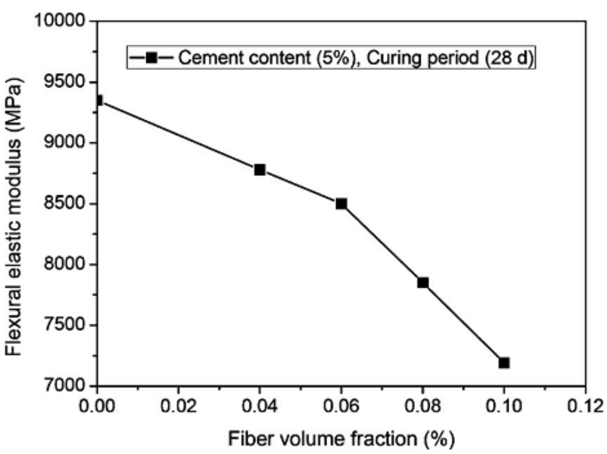
12. Zhang, P. [12] discussed the Flexural Properties of Cement-Stabilized Macadam Reinforced with Polypropylene Fibers. Four different fiber volume fractions 0.04, 0.06, 0.08, and 0.1% and four different cement contents 4, 5, 6, and 7% were used. Besides, a series of tests without mixing fibers were also carried out. By means of four-point loading method, the flexural strength and flexural modulus of elasticity of cement-stabilized macadam were measured. The results indicated that polypropylene fiber can increase the flexural strength and decrease the flexural modulus of elasticity of cement-stabilized macadam. The flexural strength and flexural elastic modulus increased with the increase in specimen curing period. When the fiber volume fraction was not beyond 0.1%, the flexural strength gradually increased and the flexural modulus of elasticity is gradually decreased with the increase in fiber volume fraction. Besides, with the increase in cement content, an increase both in the flexural strength and flexural elastic modulus was seen. Furthermore, polypropylene fiber proved to be highly effective in improving the non deformability of cement-stabilized macadam.



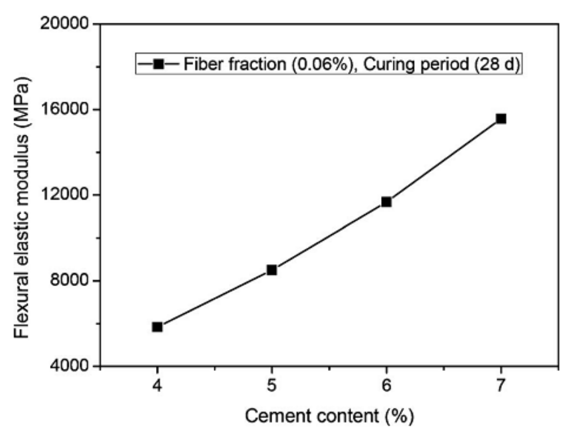
Effect of curing period on flexural strength



Effect of curing period on flexural elastic modulus



Effect of fiber volume fraction on flexural elastic modulus



Effect of cement content on flexural elastic modulus

13. Li Guo-zhong [13] investigated the mechanical properties of cement mortar composites containing different hybrid combinations of polypropylene PP fibers and polymer emulsion. Effects of different PP fiber contents as partial replacement of mortar on the mechanical properties were evaluated, and effects of different polymer emulsion contents as partial replacement of mortar on the mechanical properties were also evaluated. A group of orthogonal tests were arranged and proportioning design of PP fiber and polymer emulsion reinforced cement mortar was conducted. The experiment results showed that mixing 2.0% PP fiber and 9% polymer emulsion could enhance cement mortar's mechanical properties to a certain degree.

14. Qian, C. X. [14] reported on the optimization of fiber size, fiber content, and fly ash content in hybrid polypropylene-steel fiber concrete with low fiber content based on general mechanical properties. The results showed that a certain content of fine particles such as fly ash is necessary to evenly dispose fibers. The different size of fibers contributed to different mechanical properties, at least to a different degree. Addition of a small fiber type had a significant influence on the compressive strength, but the splitting tensile strength was only slightly affected. A large fiber type gave rise to opposite mechanical effects, which were further fortified by optimization of the aspect ratio. Also the synergy effect implemented in a hybrid fiber system was found to lead to similar significant improvements that could be realized with a monofilament fiber system having the higher total fiber content, provided the different types and sizes of fibers were properly dispersed.

15. Mindess, S. [15] investigated the Properties of Concrete Reinforced with Polypropylene Fibers under Impact Loading. In this research concrete beams containing fibrillated polypropylene fibers were tested under impact loading. An instrument drop weight impact machine was used, dropping a 345 kg mass from a height of .5 m. the specimens had dimension of 1200 X 100 X 125 mm, and were simply supported on a clear span of 960mm. The 19.1 mm fibers were added in volume concentrations from 0.1% to 0.5%. The results showed an increase of about 40% in the maximum bending load against the fracture energy which approximately doubled. An increase in the fiber volume increased the impact resistance. For all of the fiber volume studied, there was a sufficient bond with the matrix to prevent fiber pull-out; the fibers failed primarily by breaking.