Report on Design and Construction of Steel Fiber-Reinforced Concrete Elevated Slabs

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Construction of slabs in areas with weak soil conditions has commonly used pile-supported slab structural design so that the adverse effects of soil-structure interaction in terms of differential settlement, cracking, or long-term serviceability problems are avoided. In this application, the construction of slabs on closely spaced pile caps (typical span-depth ratios between 8 and 30) is referred to as elevated ground slabs (EGSs). These slabs may be subjected to moderately high loading, such as concentrated point loading of up to 44 kip (150 kN) and uniformly distributed loadings of 1000 lb/ft² (50 kN/m²). The dynamic loadings may be due to moving loads such as forklifts, travel lifts, and other material handling equipment. Fiber-reinforced concrete (FRC) has been successfully used to address the structural design of these slabs. Based on the knowledge gained, the area has been extended to a construction practice for slabs supported by columns as well. Applications are further extended to multi-story building applications. This report addresses the methodology for analysis, design, and construction of steel FRC (SFRC) slabs supported on piles or columns (also called elevated SFRC [E-SFRC]). Sections of the report address the history, practice, applications, material testing, full-scale testing, and certifications. By compiling the practice and knowledge in the analysis design with FRC materials, the steps in the design approach based on ultimate strength approach using two-way slab mechanisms are presented. The behavior of a two-way system may not require the flexural strength of conventional reinforced concrete (RC) because of redistribution, redundancy, and failure mechanisms.

Methods of construction, curing, and full-scale testing of slabs are also presented. A high dosage of deformed steel fibers (85 to 170

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lb/yd³ [50 to 100 kg/m³]) is recommended as the primary method of reinforcement. Procedures for obtaining material properties from round panel tests and flexural tests are addressed, and finite element models for structural analysis of the slabs are discussed. Results of several full-scale testing procedures that are used for validation of the methods proposed are also presented.

Keywords: ductility; durability; fiber-reinforced cement-based materials; fibers; flexural strength; jointless slab; moment-curvature response; plastic shrinkage; reinforcing materials; shrinkage; shrinkage cracking; slab-on-ground; slab-on-piles; steel fibers; steel fiber-reinforced concrete; toughness; yield line analysis.

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CHAPTER 1—INTRODUCTION

1.1—Introduction

Steel fibers have been used for over 50 years as reinforcement in many applications, such as heavily reinforced sections, shear-critical regions, slabs-on-ground, and pavements. A potential area of use of steel fibers is in the construction of slabs in areas with weak soil conditions where adverse effects due to soil-structure interaction, such as differential settlement, cracking, or long-term serviceability problems, can be treated by considering the fiber reinforcement effectiveness. In these cases, pile-supported slab structural designs have been commonly used and fiber reinforcement has shown tremendous promise. The use of steel fibers as reinforcement in these cases is due to practicality of installation, enhanced control of shrinkage cracks, durability, toughness, and cost savings in labor and equipment. The pile-supported continuous slabs are used in factories (industrial facilities), warehouses, and basements