Chapter 1

1.0 INTRODUCTION

1.1 General

Construction can be considered as one of the pillar industries in developing country like Sri Lanka. Construction industry contributes to about 7% of the Gross National Product of the country (Central Bank of Sri Lanka, 2002). Further, long term policies and programmes should have to be implemented to promote the national construction industry to support the growth of economy. However, many construction projects become notorious for quality shortfall. Concrete quality can be considered as one of the key factor as it is used in projects of different scales both urban and rural areas. Hence, improvement in quality of concrete is essential.

In Sri Lanka, reinforced concrete designs are carried out in accordance with BS 8110 : Part 1 : 1985 which has specified higher strength concretes in order to achieve adequate durability (Dias, 1991). Thus, the structural designs should be carried out for Grade 25 or 30 with Grade 25 being the minimum. These concrete strengths can be easily achieved with ready mix concrete or with weigh batching at sites. However, a survey carried out in year 2002 has revealed that about 45% of the construction sites in Sri Lanka still adopt volume batching with nominal mixes, such as 1:2:4 cement, sand and 20 mm coarse aggregates. Dias (1994) has also reported that volume batching was extensively used in Sri Lanka. There are two nominal mixes recommended for Grade 25 and 30 concretes such as 1:1.5:3 and 1:1:2 (ICTAD Specification 1988). However, these are not quite popular due to the high cost. This creates an undesirable situation where designs carried out with Grade 25 concrete could be constructed with 1:2:4 nominal mix. If it happens, concrete would have a lower characteristic strength than envisaged by the structural engineer. On the other hand, lower strength concrete could be continuously used at the expense of long term durability which may lead to costly rehabilitation work during the expected life span of the structure.

Therefore, there is an urgent need to develop nominal concrete mixes that could be adopted economically to obtain Grade 25 and 30 concretes. Such a mix would be extremely useful
in short term until Sri Lankan construction industry is developed to adopt either ready mix or weigh batching at majority of construction sites, irrespective of the scale. The development of such economical mixes was one of the objectives of this research study.

The building industry in Sri Lanka is responsible for the over exploitation of many of its natural resources. Excessive clay mining for manufacturing of bricks has led to many environmental problems such as lowering the water table, degradation of fertile lands etc (Ranasinghe, 1997). Excessive sand mining in many rivers has led to salt water intrusion and erosion of river banks. Excessive coral mining has led to severe sea erosion. One solution that can be suggested is to develop alternative building materials. Other could be the improvement of durability of new structures so that the life span could be enhanced. The use of microsilica in concrete could have applications in this area with the enhanced durability that it could offer for the concrete. Since most of the structures in Sri Lanka are still constructed with Grade 20–30 range concrete, it useful to have a detailed experimental programme in that range of strengths with locally available aggregates.

Microsilica consisting of more than 90% of amorphous Silicon Dioxide has a quite high pozzolanic potential. This was first tested in 1947 in Norway and the large scale production was started in 1970s. The present use of concrete containing microsilica is over 5 million m³/year (Lewis, 2001). The term generally used for Microsilica in the concrete industry is silica fume. Microsilica concrete has been used in major projects either to produce high strength concrete or when enhanced durability was required (Lewis and Hasbi, 2001). Microsilica concrete has proved particularly beneficial in areas where the structures are subjected to severe environmental attack such as due to hazardous ground condition (Sulphate and Chloride attack), moisture exposure or physical degradation such as abrasion and erosion (Keck, 2001). The countries extensively use silica fume include United States of America, United Kingdom, countries in the Middle East, Hong Kong, Norway, Sweden, Denmark etc. Recently, India also started using silica fume in many large construction projects upon the realization of the advantages that silica fume could offer with enhanced durability. Therefore, it is useful to determine the quality enhancement that could be achieved by using the silica fume with the fine and coarse aggregates used in Sri Lanka. This was the other objective of the study.
1.2 **Objectives**

The main objective of the research are the following.

1. Development of economical volume batched concrete mixes that can be confidently recommended for Grades 25 and 30.

2. Determination of the effectiveness of silica fume with locally available aggregates to enhance the strength and durability.

1.3 **Methodology**

In order to achieve the above objectives, the following methodology was adopted.

1. A comprehensive literature review was conducted to determine the ways and means of improving the strength and durability of concrete.

2. The extend to which the volume batching used by the Sri Lankan construction industry was assessed with a questionnaire survey conducted among practicing engineers.

3. The possibility of improving the compressive strength of concrete by changing the cement content was investigated experimentally.

4. A detailed cost study was carried out to determine the cost increments associated with the proposed mixes when compared with 1:2:4 volume batched concrete. The cost saving relative to the currently recommended grade 25 and 30 mixes were also determined.

5. The possibility of improving the compressive strength and durability of concrete by the introduction of small amount of silica fume was investigated experimentally.
1.4 Main findings

1. The questionnaire survey revealed that about 45% of the Sri Lankan construction industry uses volume batched concrete to attain its concrete demand. This is very much significant in the outstation sites where ready mix concrete is not available.

2. It is possible to use 1:2:4 (20 mrii) volume batched concrete with 20% and 30% extra cement by volume to obtain Grade 25 and 30 concretes, respectively. It is prudent to use a reasonable quantity of water so that the slump will remain in 50 to 60 mm. However, even with higher water cement ratios also, the above mixes gave sufficient strength. For these mixes, it is useful to have well graded aggregates.

3. Silica fume in 5% to 10% by weight of cement could enhance the strength and lower the sorptivity of concretes having Grades of 20, 25 and 30. It is also shown that the reduction in sorptivity could be achieved either by increasing the cement content or by using silica fume. The research study indicates that with the type of aggregate used in Sri Lanka, silica fume could be used to improve the desirable properties such as strength and impermeability. Therefore, it would be possible to explore the possibility of using silica fume with higher strength and also ready mix concrete in future.

1.5 Arrangement of Thesis

The second chapter of the thesis covers the literature about concrete technology and the use of silica fume for producing concrete.

The third chapter includes information about a questionnaire survey carried out among practicing engineers to assess the usage of volume batched concrete in the Sri Lankan construction industry.

The fourth chapter explains the experimental investigation carried out in the laboratory including compressive strength test and durability tests.
In the fifth Chapter, compressive strength results and sorptivity results were presented. These were used to develop suitable guidelines.

Chapter 6 gives the conclusions and recommendations for future work.