EFFECT OF MORTAR SPACERS OF DIFFERENT GRADES ON THE PERFORMANCE OF CONCRETE

MOHAMED ALI MOHAMOUD

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This project report is dedicated to my beloved family;

Father, Mother, Siblings and Relatives.

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ABSTRACT

Rebar spacers are crucial component in reinforced concrete structures. Their purpose is to provide and maintain cover for the reinforcement bars. Since rebar spacers are permanent part of the member their quality must be taken into consideration, failure to do so will jeopardize the durability of the whole reinforced concrete member. In this research project, the effect of mortar spacers on the durability and strength of concrete is investigated by examining the penetration of moisture and other corrosive agents such as chloride through the mortar spacer or through the concrete-spacer interface, assuming that the concrete is in good condition dense and durable. For lab experimentation, cube and prism specimens with different curing ages and conditioning were cast, the specimens were embedded with mortar rebar spacers and tested in terms of strength and durability. Strength tests have been conducted such as compressive strength and flexural, also durability tests for cube specimens were conducted including water absorption, expansion and shrinkage, chloride penetration and carbonation. Results showed that the presence of rebar spacer in concrete increases the ingression and transporting of moisture and other corrosive agents, especially at the concrete-spacer interface and when the quality of the spacer is lower compared to the quality of the concrete. Moreover, the spacer will negatively affect the flexural strength of prism specimens by initiating cracks. The spacers might seem small and hold low value during construction, but because they are permeant part of the structure and they are placed every ≤1 m along the rebars, their overall effect on ingress of corrosive agents might be significant, and that must be considered by the concrete designers and practitioners.

ABSTRAK

Alas rebar adalah komponen penting dalam struktur konkrit bertetulang. Tujuan mereka adalah untuk menyediakan dan mengekalkan perlindungan untuk bar tetulang. oleh kerana alas rebar adalah sebahagian tetap ahli kualiti ia perlu diambil kira, kegagalan berbuat demikian akan menjejaskan ketahanan keseluruhan anggota konkrit bertetulang. Dalam projek penyelidikan ini, kesan alas rebar mortar pada ketahanan dan kekuatan konkrit disiasat dengan memeriksa penembusan kelembapan dan agen menghakis lain seperti klorida melalui alas rebar mortar atau melalui antara konkrit-alas rebar, dengan anggapan bahawa konkrit adalah dalam keadaan baik padat dan tahan lama. Untuk uji kaji makmal, kiub dan spesimen prisma dengan peringkat umur pengawetan yang berbeza dan pengawetan dibuat, alas konkrit dimasukkan ke dalam sampel dan diuji dari segi kekuatan dan ketahanan. Ujian kekuatan telah dijalankan seperti kekuatan mampatan dan lenturan, juga ujian ketahanlasakan untuk spesimen kiub telah dijalankan seperti penyerapan air, pengembangan dan pengecutan, penembusan klorida dan pengkarbona tan. Hasil kajian menunjukkan bahawa kehadiran rebar dalam konkrit meningkatkan serapan dan pengangkutan kelembapan dan agen menghakis lain, terutama di antara muka konkrit-alas rebar apabila kualiti alas rebar adalah lebih rendah berbanding dengan kualiti konkrit. Selain itu, alas rebar juga akan memberi kesan negatif terhadap kekuatan lenturan spesimen prisma dengan memulakan retak. Alas rebar mungkin kelihatan kecil dan tidak kritikal semasa pembinaan, tetapi kerana mereka akan menjadi sebahagian daripada struktur dan diletakkan setiap $\leq$1 m di sepanjang tetulang, kesan keseluruhan mereka pada kemasukan agen menghakis mungkin menjadi penting, dan perlu dipertimbangkan oleh pereka dan pengamal konkrit.

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LIST OF ABBREVIATION

ASTM	**-**	American Standard Testing Materials
BS	**-**	British Standard
EN	**-**	European Standard
OPC	**-**	Ordinary Portland Cement
UPV	**-**	Ultrasonic Pulse Velocity Test

CHAPTER 1

INTRODUCTION

1.1 Background of the study

One of the ways to increase and provide durability to the reinforced concrete members is to provide concrete cover for reinforcement. Concrete cover for reinforcement is required to protect the rebar against corrosion and to provide resistance against fire. The thickness of cover depends on environmental conditions and type of structural member. The minimum thickness of reinforcement cover is indicated in the drawings, or shall be obtained from the relevant code of practice. The correct quality and depth of concrete cover to the reinforcement has a great importance, both for the durability of reinforced and pre-stressed concrete structures and for their fire resistance (concrete cover for reinforcement, 2016).

Correct cover to reinforcing steel not only affects the durability of the concrete but also the extent and severity of cracking under working loads. In condition of fire the amount of cover also governs the time scale before damage to the reinforced concrete elements occurs. The general requirements for concrete cover must be followed, so that minimum required cover is achieved. The amount of nominal cover is dependent upon the size and type of the structural member, the environmental conditions to which it will be exposed (including fire), the class of concrete, the type and size of reinforcing bar which will be used (South African RC Engineers, 2016).

Therefore, rebar spacers are required during construction to maintain cover before and during concreting and they must achieve serviceability and durability of the structural member after concreting. A rebar spacer is a device that secures the reinforcing steel or rebar in reinforced concrete to maintain the concrete cover, as the rebar is assembled in place prior to the final concrete pour. The spacers are left in place for the pour to keep the reinforcing in place, and become a permanent part of the structure (Rebar spacers, 2016).

The rebar spacers can be divided into three raw materials categories namely, concrete spacers, plastic spacers and metal spacers. The concrete spacers have the advantage of the same raw material which will improve the water tightness and strength of the concrete. Plastic spacers have the advantage of the low cost production and fast processing (Rebar spacers, 2016). The use of spacers is particularly important in areas with high earthquake activity in combination with corrosive environment. While preparing the rebar spacers two things must be taken into consideration, firstly the quality of the spacer in terms of strength and durability, secondly the type of the spacer.

1.2 Problem statement

Usually during construction and concreting of reinforced concrete members, the quality of the rebar spacer in terms of strength and durability is neglected, or not much attention is paid to it due to poor workmanship. This will result in low quality rebar spacer that will affect the durability of the whole reinforced concrete member.

Chloride, sulphate and other corrosive agents such as moisture may penetrate through the location of the rebar space. Therefore, the corrosion of steel reinforcement is believed to start from the location of the rebar spacer due to its low quality. Therefore, the strength and durability of rebar spacers must be taken into consideration.

In this research, the effect of mortar spacers on the performance of concrete in terms of strength and durability were examined. Concrete specimens with different grade of mortar spacers, tested in terms of durability and strength to check whether the mortar spacers will be a weak point that will negatively affect the performance of the concrete or not. The concrete specimens with mortar spacers were exposed to chloride solution, to determine the penetration rate of chloride ions and their effect on durability of the concrete. Also, water absorption rate and other durability and strength tests were conducted for both the mortar specimens and the concrete.

1.3 Research Objectives

In this research, the aim is to examine and test mortar spacers with different grades and their effect on the performance of the concrete in terms of strength and durability. The following objectives are targeted to be achieved.

I. To assess the durability and strength of mortar spacers with different grades.
II. To determine the effect of mortar spacers with different grades on the durability of concrete.
III. To determine the effect of mortar spacers with different grades on the strength of concrete.

1.4 Research Scope

The research was based on lab experimentation; there are many types of rebar spacers, concrete, plastic and mortar. In this research, the mortar spacers only were tested. Durability and strength tests were conducted to a number of mortar spacers and specimens of concrete prisms and cubes embedded with mortar spacers. The parameters that were considered are as follows:

- Different types of specimens (cubes and prisms)
- Different grade (strength) of mortar spacers
- Different types of durability tests conducted on concrete and mortar specimens
- Different types of mechanical tests on mortar and concrete specimens.

The purpose of testing mortar spacers and concrete specimens is to examine their durability in terms of water absorption rate, especially at the rebar spacer location and check the water absorption rate for mortar spacers as well. In addition, the uniformity of the mortar and concrete specimens with spacers were assessed by using ultrasonic pulse velocity test. Moreover, the strength development was assessed through mechanical testing (flexural and compression) throughout the curing period of concrete and mortar specimens.

The water absorption rate for cube specimens was determined by water absorption test. Some specimens were immersed inside chloride solution to determine the level of chloride ion penetration inside the specimen. All the intended tests have been conducted in accordance to standards, British and ASTM. The project scope can be summarized as follows:

- This study focused on the use of one type of spacers, which mortar spacers of different grades 20 and 30 made in the laboratory.
- All concrete specimens had the same concrete grade of 30.
- There were no reinforced concrete specimens, due to time constrain. Only concrete specimens embedded with mortar spacers.
- Various strength and durability test were conducted for this study. The tests were all done according to British Standard.

1.5 Significance of Research

In construction, rebar spacers of different types are used for reinforced concrete members to provide cover for the reinforcements. The concrete used for construction must have adequate durability to withstand deterioration during service life, also great care is taken when designing the concrete mix of the reinforced concrete. However, the rebar spacers that are permanent part of the members are usually neglected in terms of quality and durability during construction. Rebar spacers with low durability may act as a weak point and jeopardize the durability of the whole reinforced concrete member.

In previous researches and studies, there were no literature on the effect of rebar spacer on the durability and strength of concrete. In this research the effect of mortar rebar spacers on the durability and strength of concrete is assessed and determined. This research will assess the hypothesis that weak rebar spacer will negatively affect the durability of the whole concrete member.

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