UNIVERSITI TEKNOLOGI MARA

INTERNAL ARCHING ACTION WITHIN TOP DECK SLAB OF A BOX GIRDER

ABDULLAH ZAID MOHAMMED ZAID

Thesis submitted in fulfillment
of the requirements for the degree of
Doctor Philosophy

Faculty of Civil Engineering

November 2019

ABSTRACT

Arching structures have been used in architecture and engineering for millennia for their aesthetic and to carry loads. More recently the internal arching in restrained reinforced concrete slab structures has also started to be utilised. The beneficial effect of internal arching or compressive membrane action (CMA) has been incorporated into some design and assessment codes and standards for beam and slab bridges within certain geometric parameters. Haunched slabs or slabs with larger span to depth ratio, as in typical box girders, are not covered in these codes. Thus, this study aims to utilise the internal arching action within the box girder top slab to optimise the deck design. Therefore, for the attainment of achieving the study goal, this research was subdivided into two main components. Firstly, to propose a practical theoretical approach for undertaking analysis of the box girder slabs utilising the Internal Arching Action. Secondly, to demonstrate the influence of Geometric Arching Action on the slab capacity via laboratory experimental work. The study also opts to differentiate between the slab's strength enhancement due to CMA and the Arching Action as the existing definitions are generic. The study determined the components contributing to the slab capacity under the arching action theory. The components are, the slab flexural capacity resulted from the reinforcement, the Frame Action (FA), the Geometric Arching Action (GAA), and lastly the CMA. From the experimental investigation, the influence of Geometric Arching Action was demonstrated and findings drawn. The proposed analyses showed significant reinforcement reduction by utilising the arching action theory in comparison to the current practice. Material savings of 45% of the slab reinforcement was achieved utilising the Internal Arching Action factors other than CMA, including the CMA the savings reached to about 55%. The analyses methods then were validated versus a full-scale experimental work from the literature and the results showed good agreement. The experimental work illustrates how the haunches significantly enhanced the slab capacity. The slab with small haunch increased the capacity by 125%) in comparison to the slab tested without haunches. The findings of the study demonstrated the Internal Arching Action contribution to the slab capacity and proposed a practical theoretical analysis method which easily can be adopted by engineers in the industry.

ACKNOWLEDGEMENT

Firstly, I wish to thank Allah for giving me the opportunity to embark on my PhD and for completing this long and challenging journey successfully. My gratitude and thanks go to my former supervisor Datin Puan Sri Prof. Dr. Hanizah Abdul Hamid and my supervisor Prof. Dr. Azmi Ibrahim. I would never forget the personal advices and supports I got from them during hard times with major decisions I needed to take.

My appreciation goes to the Heavy Structural and Computer Laboratories staff and to my brother Ahmed and Brother in-law Akeel for whom provided the facilities and assistance during the experimental works. Special thanks to my former colleagues in RB International specially David Collings and friends for helping me with this accomplishment.

Finally, this thesis is dedicated to the loving memory of my family specially my mother . My wife and life who has contributed the most to this achievement by providing me all the encouragement persistence and determination during the ups and downs. Without her standing beside me this achievement would never exist. Wouldn't forget the passion I get when I see my two kids and< and energy I received letting them proud of their father achievement. This piece of victory is dedicated to all who influenced my life.

TABLE OF CONTENTS